THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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GPS CAR COMPUTER – PART 1

A very high spec. project with USB interface, featuring:

- Digital speedometer with over-speed alarm
- Fuel economy meter
- Distance and time to destination
- Digital clock with GPS accuracy
- Current altitude, latitude and longitude

GPS CAR COMPUTER
93km
0h 52m
SET

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An add-on board for our most popular DAC project

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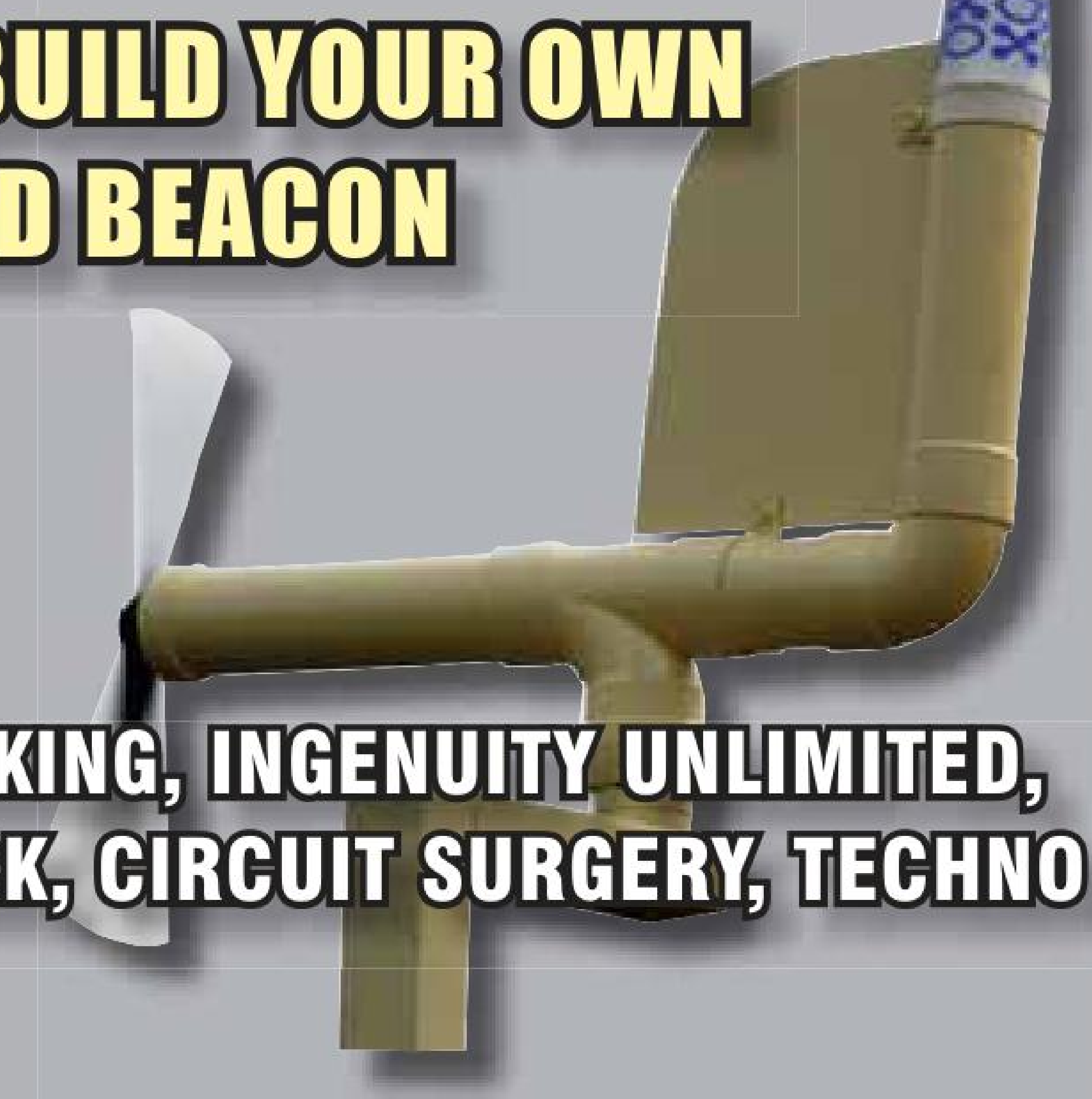

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New 8-bit Microcontrollers with integrated configurable logic in 6- to 20-pin packages

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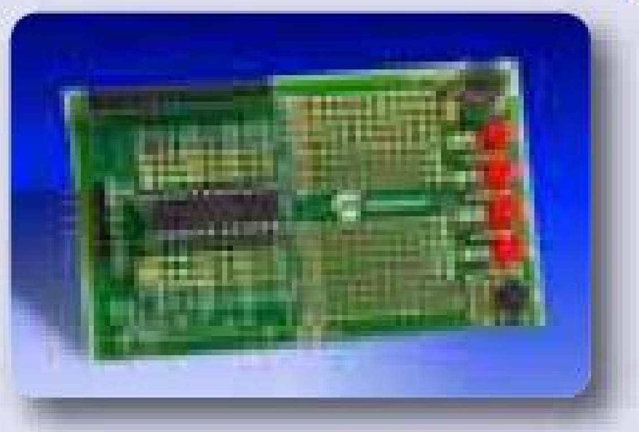

PICkit™ Low Pin Count Demo Board - DM164120-1

Free CLC Configuration Tool:
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● POPULAR FEATURES ●
VOL. 41. No 1 January 2012

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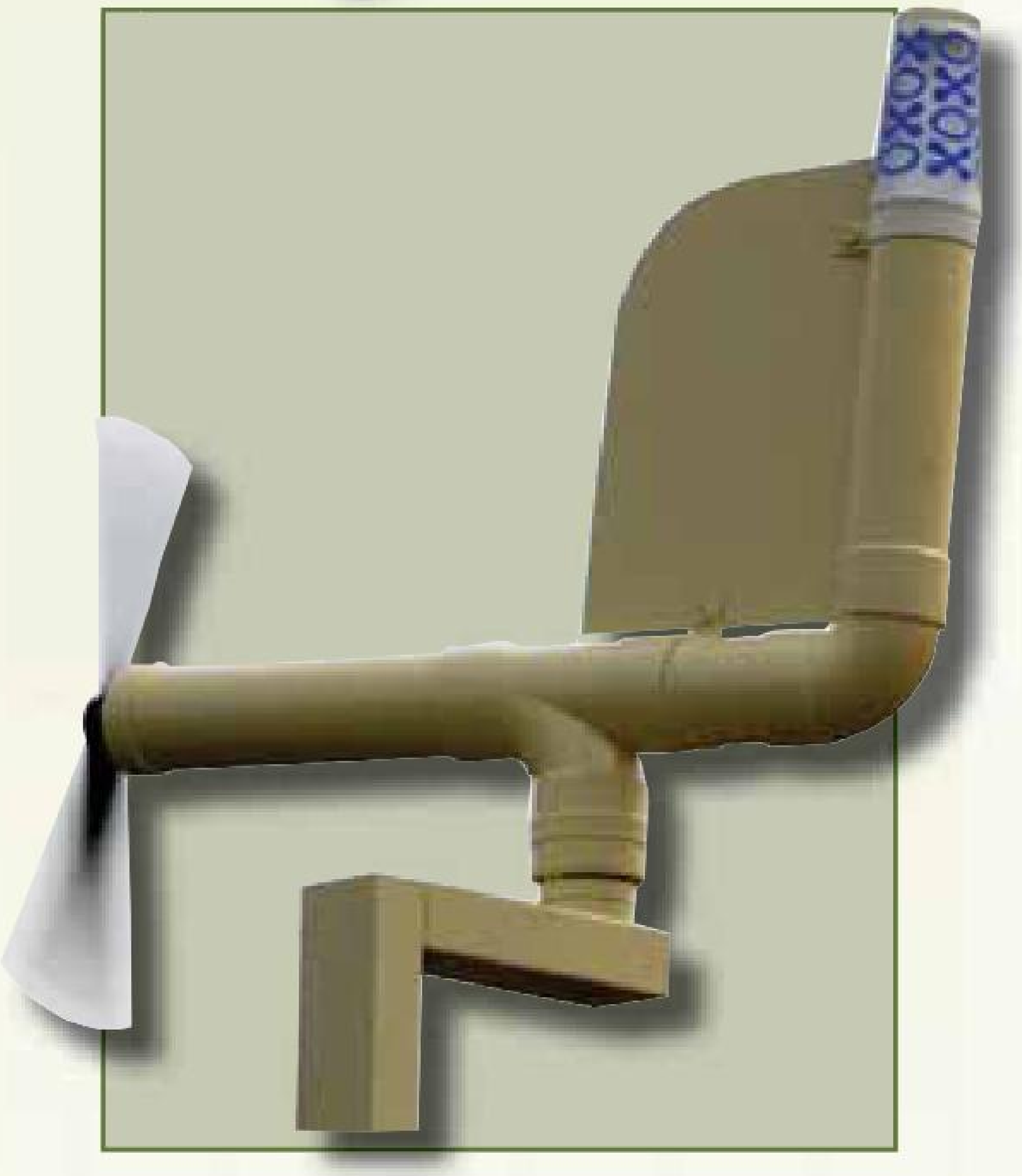
GPS CAR COMPUTER
93km
0h 52m



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Our February 2012 issue will be published on Thursday 12 January 2012, see page 72 for details.

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Ho! Ho! Ho! Christmas 2011 is on it's way but
DON'T PANIC!!
We have some fantastic gift ideas for young (and older) enquiring minds

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An electronics course in a box! All assume no previous knowledge and require NO solder. See website for full details

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Festive Fun Electronic Project Kits
Choose from 500 plus electronic kits. Soldering required.

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Order Code MK100KT

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Order Code MK170KT

See our website for even more great gift ideas!

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www.QuasarElectronics.com

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

LED Roulette Kit - £18.95
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Solar Bug Kit - £17.95
Order Code MK185KT

Robot Kits

These educational electronic robot kits make a great introduction to the exciting world of robotics. Some require soldering. See website for details

Robotic Arm - £49.95
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Crawling Bug - £15.95
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Order Code SOL050

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Order Code APS230

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Hobby Meter - £7.95
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Everyday Practical Electronics
FEATURED KITS January 2012

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested Down Under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

Minimaximite Controller Kit

KC-5505 £18.25 plus postage & packing

A versatile and intelligent controller to interface with your creations, such as home automation. Features 20 configurable digital/analog I/O ports, 128K RAM and 256KB flash memory to hold your program and data. Design and test in MMBasic over a USB link from your PC, then disconnect the PC and the programs continue to operate. Alternatively, hard wire a PC monitor, keyboard, SD card reader and amplified speaker to work independent of a PC.

- Requires 2.3 - 3.6VDC (2 x AA or use plugpack MP-3310 £7.00). Kit supplied with PCB, pre-programmed and pre-soldered micro, and electronic components.
- PCB: 78(L) x 38(W)mm

G-Force Meter Kit

KC-5504 £18.25 plus postage & packing

Measure the G-forces on your vehicle and it's occupants during your next lap around the race circuit, or use this kit to encourage smoother driving to save petrol and reduce wear and tear. Forces (+/- 2g) are displayed on the 4-digit LED display. Also use it to measure G-forces on a boat crashing over waves or on a theme park thrill ride. Kit includes PCB with pre-mounted SMD component, pre-programmed microcontroller and all onboard electronic components.

NEW
2011
F200

- Requires 2 x AA batteries
- PCB: 100(L) x 44(W)mm

Note: We supply the PCB with the SMD component already mounted on the board to save time and frustration.

Featured in EPE November 2011

Improved Low Voltage Adaptor

KC-5463 £6.75 plus postage & packing

This handy regulator will let you run a variety of devices such as CD, DVD or MP3 players, digital cameras or even powered speakers from the power supply inside your PC. This unit can supply either 3V, 5V, 6V, 9V, 12V or 15V from a higher input voltage at up to four amps (with a suitable heatsink). Kit includes screen printed PCB and all specified components.

- PCB Dimensions: 108(L) x 37(W)mm

Note: To ensure trouble free 4 amp output, a heatsink with a thermal resistance of 1.4 degrees C per watt, and an input voltage 3VDC above the output voltage is required.

Featured in EPE November 2007

240V 10A Deluxe Motor Speed Controller Kit

KC-5478 £36.25 plus postage & packing

The deluxe motor speed controller kit allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation and low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

Note: Requires UK mains socket or adaptor

Featured in EPE November 2011

Digital Audio Delay Kit

KC-5506 £36.25 plus postage & packing

Corrects sound and picture synchronisation ("lip sync") between your modern TV and home theatre system. Features an adjustable delay from 20 to 1500ms in 10ms steps, and handles Dolby Digital AC3, DTS and linear PCM audio with sampling rate of up to 48kHz. Connections include digital S/PDIF and optical Toslink connections, and digital processing means there is no audio degradation. Kit includes PCB with overlay and pre-soldered SMD IC, enclosure with machined panels, and electronic components.

- 9-12VDC power supply required
- Universal IR remote required - use AR-1729 £8.75
- PCB: 103(L) x 118(W)mm

45 Second Voice Recorder Module

KC-5454 £16.00 plus postage & packing

Will record two, four or eight different messages for random-access playback or a single message for "tape mode" playback. It also provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9 - 12VDC.

- PCB: 120(L) x 58(W)mm
- Supplied with silk screened and solder masked PCB and all electronic components

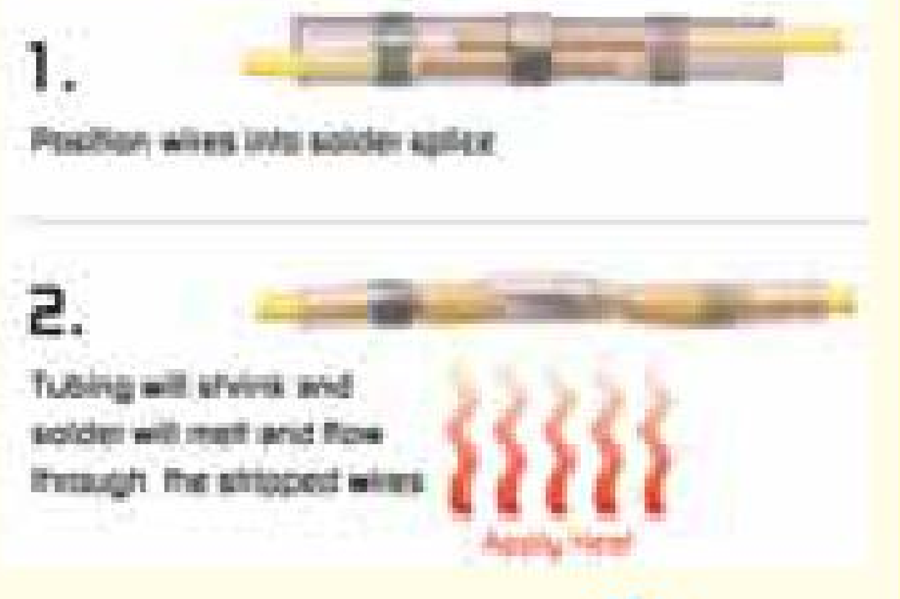
Featured in EPE Febuary 2011

Solder Splice Heatshrink - Pack of 5

Solder splice heatshrink allows you to quickly join two cables by sliding a tube over the join in two cables and heating as you would any other shrink tube. As the tube shrinks the solder melts to electrically connect the wires resulting in a join which is reliable and well insulated.

- Three sizes available in packs of 5

WH-5670 40(L) x 2.7(Dia.)mm £1.75
WH-5671 40(L) x 4.5(Dia.)mm £1.75
WH-5672 40(L) x 6.0(Dia.)mm £1.75


1.
Position wires into solder splice
2.
Tubing will shrink and solder will melt and flow through the stripped wires
Apply Heat

Note: Pricing does not include postage & packing

From £1.75

MORE INFO AVAILABLE ONLINE

Ultrasonic Antifouling Kit For Boats

KC-5498 £90.50 plus postage & packing

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB: 104(L) x 78(W)mm

Pre-built units now available:
Dual output, suitable for vessels up to 14m (45ft)
YS-5600 £309.25
Quad output, suitable for vessels up to 20m (65ft)
YS-5602 £412.25

DC Relay Switch Kit

KC-5434 £6.25 plus postage & packing

An extremely useful and versatile kit that enables you to use a tiny trigger current - as low as 400µA at 12V to switch up to 30A at 50VDC. It has an isolated input, and is suitable for a variety of triggering options. The kit includes PCB with overlay and all electronic components with clear instructions.

Featured in EPE December 2011

Theremin Synthesiser Kit MkII

KC-5475 £27.25 plus postage & packing

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna. It's now easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.

- Complete kit contains PCB with overlay, pre-machined case and all specified components
- PCB: 145(L) x 85(W)mm

Featured in EPE March 2011

3 - 9VDC to DC Converter Kit

KC-5391 £6.00 plus postage & packing

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.

- PCB: 59(L) x 29(W)mm
- Kit supplied with PCB, and all electronic components.

Featured in EPE June 2007

Jaycar Electronics

Freecall order: 0800 032 7241

ARDUINO - Simple to Advanced Projects

ARDUINO DEVELOPMENT KITS

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs (includes Jaycar stepper motors). Arduino projects can be stand-alone, or they can be communicated with software running on your computer. These Arduino development kits are 100% Arduino compatible. Designed in Australia and supported with tutorials and guides. See website for complete Arduino range.

"Eleven" Arduino-compatible development board

XC-4210 £14.50 plus postage & packing

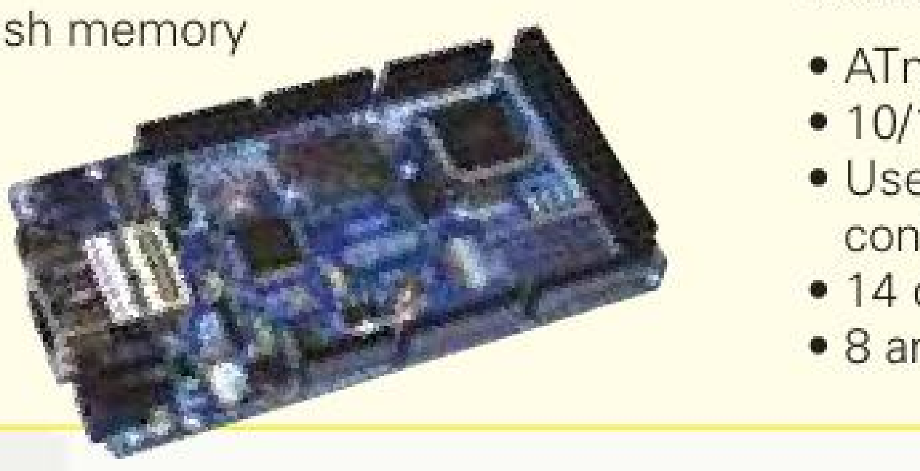
An incredibly versatile programmable board for creating projects. Easily programmed using the free Arduino IDE development environment, and can be connected into your project using a variety of analog and digital inputs and outputs. Accepts expansion shields and can be interfaced with our wide range of sensor, actuator, light, and sound modules.

- ATmega328P MCU running at 16MHz
- 14 digital I/O lines (6 with PWM support)
- 8 analog inputs

EtherMega, Mega sized Arduino compatible with Ethernet

XC-4256 £43.25 plus postage & packing

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.



- ATmega2560 MCU running at 16MHz, large Flash memory
- 10/100base-T Ethernet built in
- 54 digital I/O lines
- 16 analog inputs
- MicroSD memory card slot
- Prototyping area
- Switchmode power supply

USBDroid, Arduino-compatible with USB-host support

XC-4222 £25.50 plus postage & packing

This special Arduino-compatible board supports the Android Open Accessory Development Kit, which is Google's official platform for designing Android accessories. Plugs straight into your Android device and communicates with it via USB. Includes a built-in phone charger.

- ATmega328P MCU running at 16MHz
- USB host controller chip
- Phone charging circuit built in
- 14 digital I/O lines (6 with PWM support)
- 8 analog inputs
- MicroSD memory card slot

EtherTen, Arduino-compatible with Ethernet

XC-4216 £25.50 plus postage & packing

This Arduino-compatible development board includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built in
- Used as a web server, remote monitoring and control, home automation projects
- 14 digital I/O lines (6 with PWM support)
- 8 analog inputs

Getting Started with Arduino

BM-7130 £9.75 plus postage & packing

This book explains what Arduino is, how it works and what you can do with it. It also includes a project to build, complete with how to write the code to make it work.

- Softcover, 118 pages. 216 x 140mm

Arduino Modules

We have a huge range of simple to advanced add-ons that provide input for your Arduino projects. Visit our website for our full range and more details.

N-MOSFET Driver & Output Module	XC-4244 £2.75
Logic Level Converter Module	XC-4238 £2.75
Shift Register Expansion Module	XC-4240 £2.75
Light Sensor Module	XC-4228 £3.75
Sound & Buzzer	XC-4232 £3.75
Microphone Sound Input Module	XC-4236 £3.75
Hall Effect Magnetic & Proximity Sensor Module	XC-4242 £3.75
Full Colour RGB LED Module	XC-4234 £3.75
Temperature Sensor Module	XC-4230 £6.25
3-Axis Accelerometer Module	XC-4226 £7.25
Humidity & Temperature Sensor Module	XC-4246 £7.25

ProtoShield Basic

XC-4214 £1.75 plus postage & packing

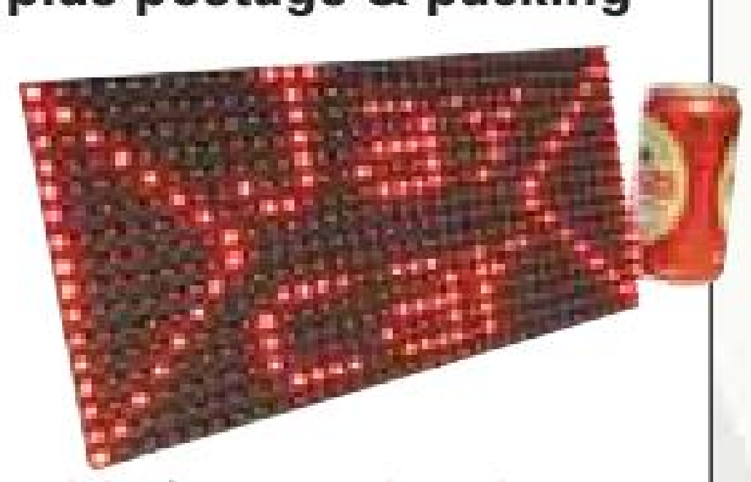
A prototyping shield for the Eleven (XC-4210) and USBDroid (XC-4222) both featured above. Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

- Gold-plated surface

Large Dot Matrix Display Panel

XC-4250 £14.50 plus postage & packing

A huge dot matrix LED panel to connect to Eleven, EtherTen and more! This bright 512 LED matrix panel has on-board controller circuitry designed to make it easy to use straight from your board. Clocks, status displays, graphics readouts and all kinds of impressive display projects are ready to create with this display's features.

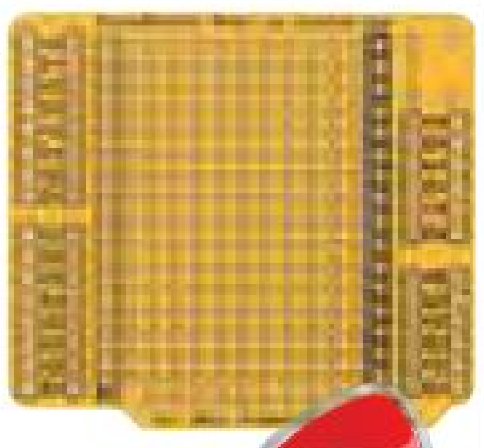


- 32(L) x 16(W)mm high brightness Red LEDs (512 LEDs total) on a 10mm pitch
- 5V operation
- Viewable over 12 metres away
- Tough plastic frame
- Controller IC's on board, simple clocked data interface
- Arduino compatible library, graphics functions and example support

ProtoShield Short

XC-4248 £2.00 plus postage & packing

A dedicated short version prototyping shield for EtherTen and EtherMega. This special prototyping shield is designed to fit neatly behind the RJ45 Ethernet jack, allowing you to stack your Ethernet-based projects right on top with standard headers.

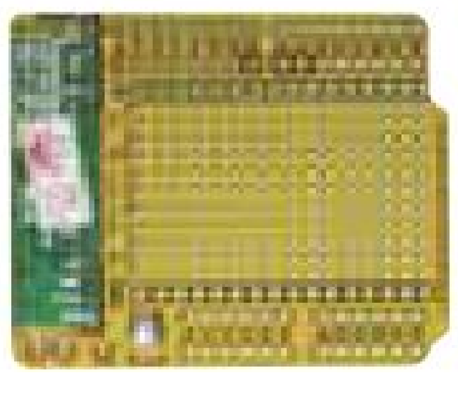


- Pads available to fit a reset button
- Gold-plated surface for maximum durability

Receiver Shield 433MHz

XC-4220 £11.00 plus postage & packing

This receiver shield lets you intercept 433MHz OOK/ASK signals, decoding them in software on your Arduino. All the Arduino headers are broken out to solder pads, and GND and 5V rails are provided for convenience.



- Reset button
- Blue "power" LED
- Red and green user-defined LEDs
- Gold-plated surface
- 433.92MHz tuned frequency

LCD & Keypad Shield

XC-4218 £11.00 plus postage & packing

Handy 16-character by 2-line display ready to plug straight in to your Arduino, with a software-controllable backlight and 5 buttons for user input. The display is set behind the shield for a low profile appearance and it includes panel mounting screw holes in the corners.

- 2 rows of 16 characters
- Supported by a driver library
- Software-controlled backlight
- Reset button
- Dimensions: 85(W) x 54(H) x 12(D)mm (24mm including header pins)

Post & Packing Charges

Order Value	Cost
£10 - £49.99	£5
£50 - £99.99	£10
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£200 - £499.99	£30
£500+	£40

Max weight 12lb (5kg)

Heavier parcels POA

Minimum order £10

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- **Minimum order £10**

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FAX: +61 2 8832 3118*
EMAIL: techstore@jaycarelectronics.co.uk
POST: P.O. Box 107, Rydalmere NSW 2116 Australia

*Australian Eastern Standard Time
(Monday - Friday 09.00 to 17.30 GMT + 10 hours)
Expect 10-14 days for air parcel delivery

Order online: www.jaycarelectronics.co.uk

Jaycar Electronics

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Kit Catalogue Available

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www.esr.co.uk

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Digital Echo Chamber Kit
A compact sound effects kit, with built-in mic or line in, line out or speaker (500mW). 4 Adjustment controls
Power: 9Vdc 150mA
MK182 Velleman kit £11.43

3rd Brake Light Flasher Kit
Works with any incandescent or LED rear centre brake light. Flashes at 7Hz for 5 or 10 times, adjustable re-triggering.
Power: 12Vdc max load 4A
MK178 Velleman kit £6.30

Digital Clock Mini Kit
Red 7 Segment display in attractive enclosure, automatic time base selection, battery back-up, 12 or 24Hr modes.
Power: 9Vac or dc
MK151 Velleman kit £15.09

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A simple security kit with many applications. RFID technology activates a relay, either on/off or timed. Supplied with 2 cards, can be used with up to 25 cards. Power: 9Vac or dc
MK179 Velleman kit £14.25

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Powered by two subminiature motors, this robot will run towards any light source. Novel shape PCB with LED eyes.
Power: 2 x AAA Batteries
MK127 Velleman kit £9.02

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K8060 Velleman kit £12.85
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EPE EVERYDAY PRACTICAL ELECTRONICS

Thanks Google

We like to think that one of the key hallmarks of modern life is the transformative nature of information and its manipulation with digital technology. But information has always been vital; if asked what was the most important event of the last hundred years, many might say the Second World War, or to be precise, the allies' victory. It is estimated that even in that pre-germanium (let alone silicon) era, two years were knocked off the war's length thanks to the information gathered at Britain's main decryption establishment, Bletchley Park. And that information was useable thanks to the ingenious prototype 'computers' made there.

The hard work and dedication of many volunteers has turned Bletchley Park (near Milton Keynes) into a very successful museum, 'with enough activities and exhibitions to occupy most families for a whole day, from wartime toys to working computers' (see: **www.bletchleypark.org**).

The Bletchley Park Trust's work is ongoing, and like most of us, finds that there is never enough money. So, it was good to hear that the US search engine giant Google has recognised the unique role Bletchley played in the birth of the computer industry, and has pledged financial support to help purchase the academic papers of Alan Turing, the genius behind the code-breaking theory at Bletchley. Google has also promised to support extensive restoration work at Bletchley Park.

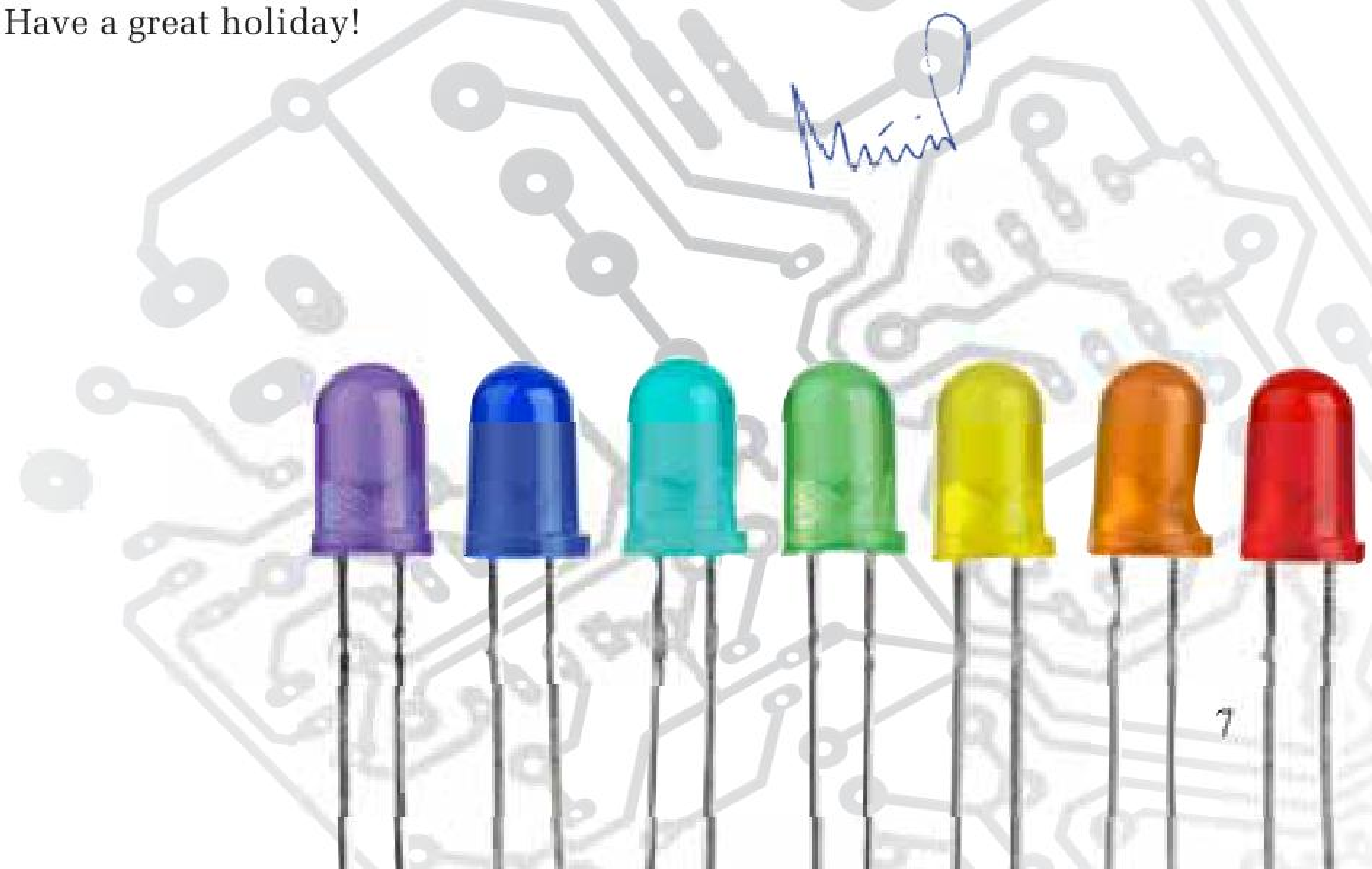
Google's motto is 'Don't be evil', and it's nice to see a corporate giant from California doing the right thing, and actively supporting a fascinating part of British computing history.

Happy Christmas!

This is the last editorial before the New Year, so I'd like to sign off by wishing our loyal readers the very best for Christmas and 2012, from all the staff at Wimborne Publishing. We hope you have a restful, silicon-filled break, and look forward to providing you with the very best in projects, ideas, techniques, news and tips over the next 12 months.

Finally, if, like me, you hate being asked what you'd like for Christmas, and suspect that your first choice of a British Racing Green V12 E-type convertible is yet again unlikely to fit under the Christmas tree, then why not ask for a subscription to *EPE*? You have the choice of traditional paper delivery to your door, or you can download the magazine from the Internet… it beats socks, lasts longer than a 'bottle of cheer' and will provide a fantastic read throughout the year.

Have a great holiday!



NEWS

A roundup of the latest Everyday News from the world of electronics

Return of limited-play, disposable DVDs by Barry Fox

Disposable, limited-play discs – DVDs that look ordinary, but play only for a day or two after being removed from a sealed sleeve – are back. French replicator MPO unveiled the latest attempt at making the old idea a commercial success at the AGM of the UK's British Video Association in London.

Previous systems – SpectraDisc, Flexplay and EZ-D – were trialled in 2003/4, as an alternative to returnable rented discs. Dyes trapped in the disc surface changed colour after exposure to light, so the player laser could no longer read the disc.

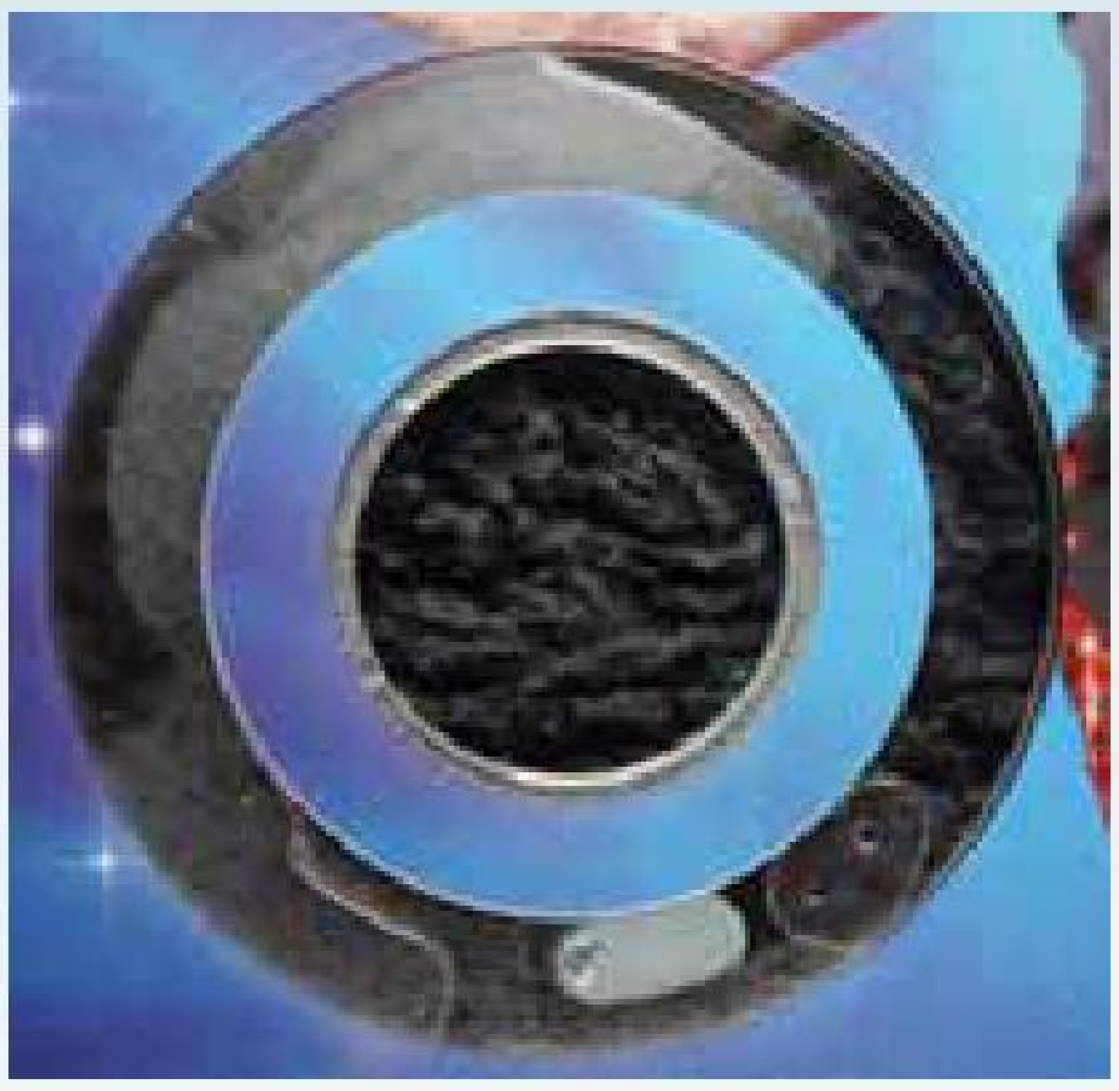
A corrosive time

The new MPO system uses a corrosive fluid, which spreads from a reservoir near the disc centre to the vital table of contents (TOC), which digitally indexes the disc content. The fluid eats the reflective metal coating on the disc plastic and once the TOC has been eaten, the disc will not play.

As with previous 'self-destruct' systems, MPO is pitching the system as an alternative to traditional rental applications and for non-traditional retail sectors; eg, local stores that do not normally sell or rent DVDs can now offer disposable discs for impulse purchase at the checkout.

MPO unveiled the system by giving everyone attending the BVA AGM a sample DVD. The sleeve was labelled as: 'compatible with all DVD players… for 48 hours after its first viewing'. I tested a copy; it played fine after 24 hours but, exactly as intended, would not play after 48 hours.

Only sketchy details of the process were available at the BVA event, but Lee Patterson, business development director of MPO in the UK, later confirmed that DVD-D has the same capacity as a DVD5, and plays video for around 130 minutes. The chemical mix determines whether the disc plays for 24, 48 or 72 hours, he said.



A limited-play DVD – the liquid mechanism is clearly visible at the bottom of the image

'The discs at the AGM were part of three test batches we have made to find the ideal mix' Patterson later added. 'MPO is making samples to attract interest. This is the first time we have shown them. We want to talk to content owners. The samples are being made at our factory near Le Mans in France. Of course, they cost more to produce, but automation of the process will reduce the price'.

The sample DVDs given out at the BVA AGM referred to: **www.dvd-d.com**, which referred on to developer FDD Technologies AG of Zug, Switzerland (**www.fddtechnologies.ch**).

FDD calls the disc 'DVD-D' and claims it is 'compatible with any type of DVD drive (DVD players, DVD-ROM drives, DVD game devices)'.

FDD claims that the self-destruct mechanism can be fine-tuned to offer a choice of single viewing, where 'at the end of the movie, you cannot play it anymore'; or eight-hour viewing, 'when the movie starts, you can watch it for eight hours. After this limited time, you cannot play it anymore'; and 48 hours, where 'when the movie starts, you can watch it for 48 hours. After this limited time, you cannot play it anymore.'

Environmental friendly

The MPO sample sleeve assures, 'This product respects the environment and is recyclable... the DVD and sleeve is recyclable'.

Reminded of the criticism that arose ten years ago about the impact of disposable discs on landfill, Lee Paterson says: 'People are now more understanding. Families sort rubbish for separate bins. It is no longer a case of straight to landfill.

The plastic disc and card package can both be recycled with other plastics and paper. I'm sure that with the introduction of DVD-D we can spend time promoting and further educating the consumer, something I will be speaking with content owners and retailers about to ensure its success.'

Centre point

MPO is cagey on technical details, saying only that the corrosive fluid is 'like saline' and harmless. However, patent searches conducted by CED revealed the system. A sticky fluid, such as a mix of water and glycol, with a corrosive acid or alkaline additive, is trapped in a reservoir under the disc surface, near the disc centre.

The centre mass of the disc does not coincide with its centre of rotation. So, when the disc spins in a player it is slightly unbalanced and this causes vibration that moves the corrosive fluid into contact with the metal TOC. As the fluid moves, it rebalances the disc, reducing vibration.

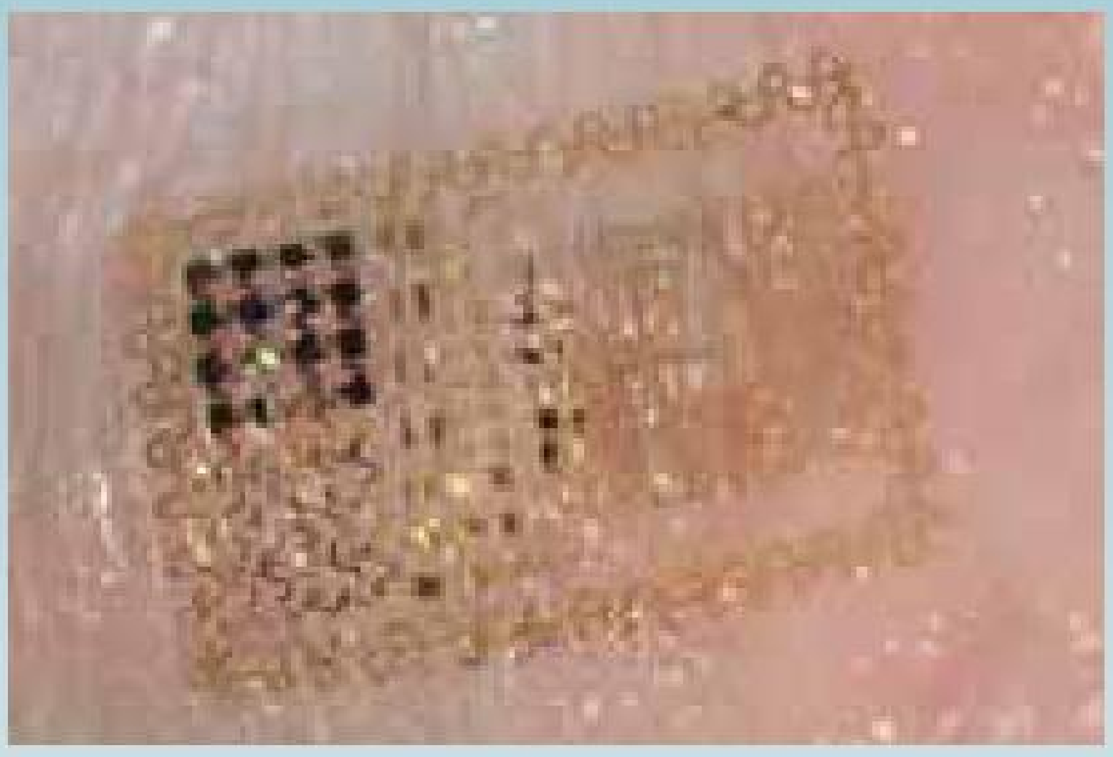
As with previous systems, there is nothing to stop the owner using a PC and unauthorised (but widely available) copy software to make a permanent copy of the disc while it still plays.

ELECTRONIC 'TATTOOS'

Engineers at the University of Illinois in the US have developed a device platform that combines electronic components for sensing, medical diagnostics, communications and human-machine interfaces, all on an ultra-thin 'skin-like' patch that mounts directly on to the skin with the ease, flexibility and comfort of a temporary tattoo.

The circuit bends, wrinkles and stretches with the mechanical properties of skin. The researchers have demonstrated their concept through a diverse array of electronic components mounted on a thin, rubbery substrate, including sensors, LEDs, transistors, radio frequency capacitors, wireless antennas, and conductive coils and solar cells for power.

The patches are initially mounted on a thin sheet of water-soluble plastic, then laminated to the skin with water – just like applying a temporary tattoo. Alternately, the electronic components can be applied directly to a temporary tattoo itself, providing concealment for the electronics.

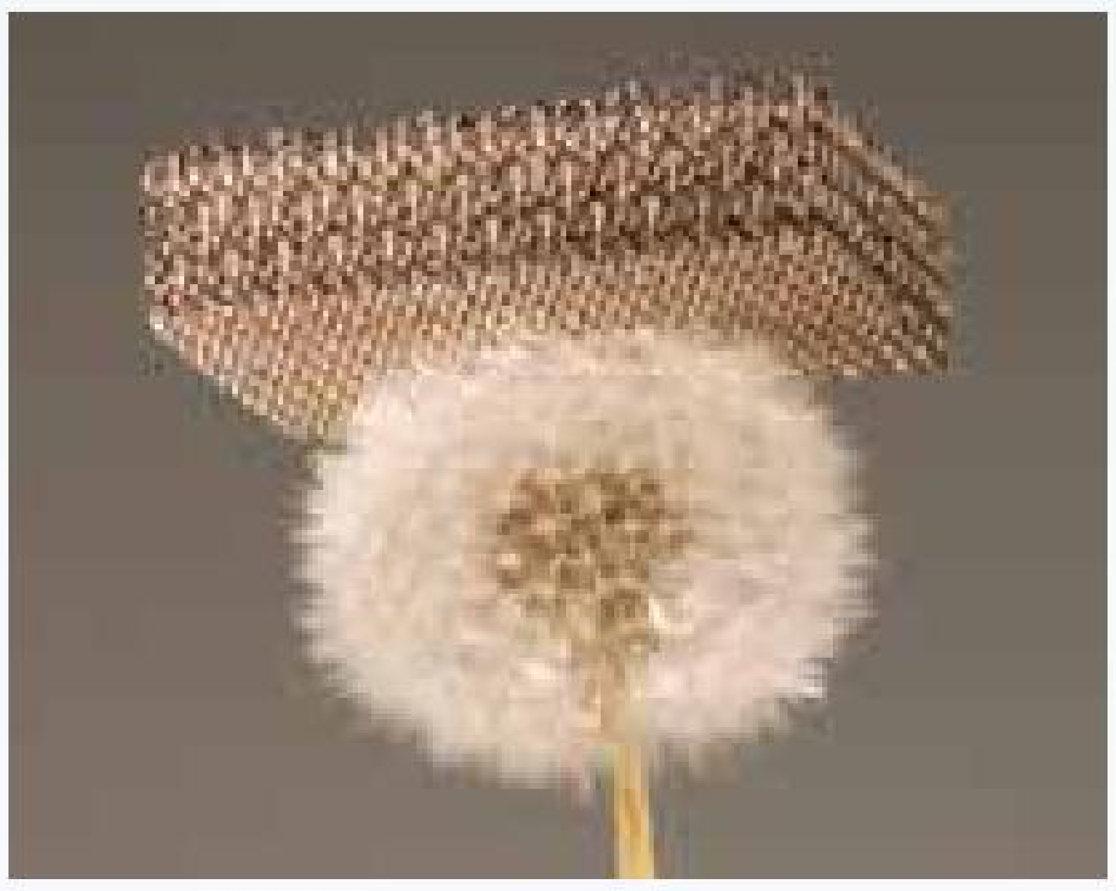


The circuits' filamentary serpentine shape allows them to bend, twist, scrunch and stretch just like skin. (Photo: John Rogers)

'We think this could be an important conceptual advance in wearable electronics, to achieve something that is almost unnoticeable to the wearer,' said Illinois electrical and computer engineering professor Todd Coleman, who co-led the multi-disciplinary team. 'The technology can connect you to the physical world and the cyberworld in a very natural way that feels very comfortable.'

Skin-mounted electronics have many biomedical applications, including EEG and EMG sensors to monitor nerve and muscle activity. One major advantage of skin-like circuits is that they don't require conductive gel, tape, skin-penetrating pins or bulky wires, which can be uncomfortable for the user and limit coupling efficiency. They are much more comfortable and less cumbersome than traditional electrodes.

MICRO-LATTICE



New battery electrode material – a 'micro-lattice' with a wall thickness 1000 times thinner than a human hair

Researchers have created a 'micro-lattice' structure of interconnected hollow tubes with a wall thickness of 100nm, 1000 times thinner than a human hair.

The engineers at HRL Laboratories in Malibu, California have developed the world's lightest material with a density of 0.9mg/cm^3, approximately one hundred times lighter than Styrofoam. (It is even lighter than air at 1.2mg/cm^3). It is claimed that the results of their research (a collaborative effort with CalTech and the University of California), redefines the limits of lightweight materials thanks to its unique 'micro-lattice' cellular architecture.

Using an innovative fabrication process, the team was able to make a material that consists of 99.99% open volume by designing the 0.01% solid at the nm, µm and mm scales. As well as having useful mechanical properties (acoustic, vibration or shock energy damping), the material could be used for battery electrodes.

Tiny ADC from TI

Texas Instruments has introduced a family of 16-bit analogue-to-digital converters (ADCs) in a package measuring just 2.0 × 1.5 × 0.4mm – 70% smaller than the nearest competition. This family supports battery monitoring, portable instrumentation, industrial process control, smart transmitters, medical instrumentation and other industrial and consumer systems.

Designed for precision, power efficiency and ease of use, the ADS1115 family performs conversions at programmable data rates up to 860 samples per second, consuming just 150 µA (typical) of supply current and operating down to 2V.

New USB Pico scope

Pico
PicoScope

The new PicoScope 2205 MSO is a two-channel oscilloscope combined with a 16-channel logic analyser, all in one compact, portable USB instrument. It lets users view analogue waveforms and digital data on the same screen with easy-to-use PicoScope software.

The analogue bandwidth is 25MHz and the digital channels can accept signals as fast as 100MHz. The maximum sampling rate is 200MS/s. The PicoScope 2205 MSO is suitable for general-purpose analogue and digital circuit design, testing and troubleshooting. As it's USB-powered, there is no AC adapter to carry: just plug it into your PC or laptop and start the software. The 48k-sample buffer is large enough to store multiple captures in rapid sequence, from as little as 2µs.

The PicoScope software (included) delivers a high–resolution, uncluttered display and a range of advanced signal processing features: spectrum analyser, automatic measurements with statistics, channel maths, reference waveforms, multiple scope and spectrum views, I^{2}C, UART, SPI and CAN bus serial decoding, XY mode, advanced triggers, mask limit testing, and colour persistence display modes.

The 16 digital inputs can be displayed individually or in arbitrary groups labelled with binary, decimal or hexadecimal values. A separate logic threshold from –5V to +5V can be defined for each 8-bit input port. The software development kit (SDK), also included, allows you to control the new scopes using your own software. The SDK and PicoScope are compatible with Microsoft Windows XP, Vista and Windows 7. Example programs in C, Excel and LabView are included.

The new PicoScope 2205 MSO is available now, priced at only £349 for the oscilloscope alone or £399 as a kit with two passive x1/x10 probes, a logic cable and test hooks. A five–year warranty is included. For more details, see: **www.picotech.com**

GPS CAR COMPUTER
93km
0h 52m
SET

GPS Car Computer

Part 1: By Geoff Graham

This project was inspired by requests from a number of readers. Essentially, they said that the GPS module was great for obtaining a precise time... but could we produce a project that used its full capabilities for use in a vehicle?

THIS PROJECT is the result of readers' requests. It is small enough to sit on the dash or mount in the radio-sized (DIN) blank panels that many vehicles have.

It is also relatively simple to construct, and uses just a few active components on a single PC board with no other wiring. There is no setup or calibration required – just plug it in and away you go!

It is designed for use in a moving vehicle, where your attention should not be distracted from the road for any longer than is necessary. Therefore, data, such as your speed, is displayed in easily-readable 14mm-high digits, while a button press will show other data as needed.

You can also set it to automatically step through the data screens for complete hands-off operation.

A key component is the graphic LCD, which allowed a great deal of design flexibility. Three fonts are used, ranging from a 'jumbo' font to a small detailed font; some areas also use graphic symbols.

The display uses a green LED backlight, with the brightness automatically changed between day and night settings, which can be easily configured.

A USB interface allows you to plug the device into a laptop for a complete navigation experience, with your position accurately pinpointed on a map. The USB interface also allows you to upload new firmware and reprogram the device without any special hardware.

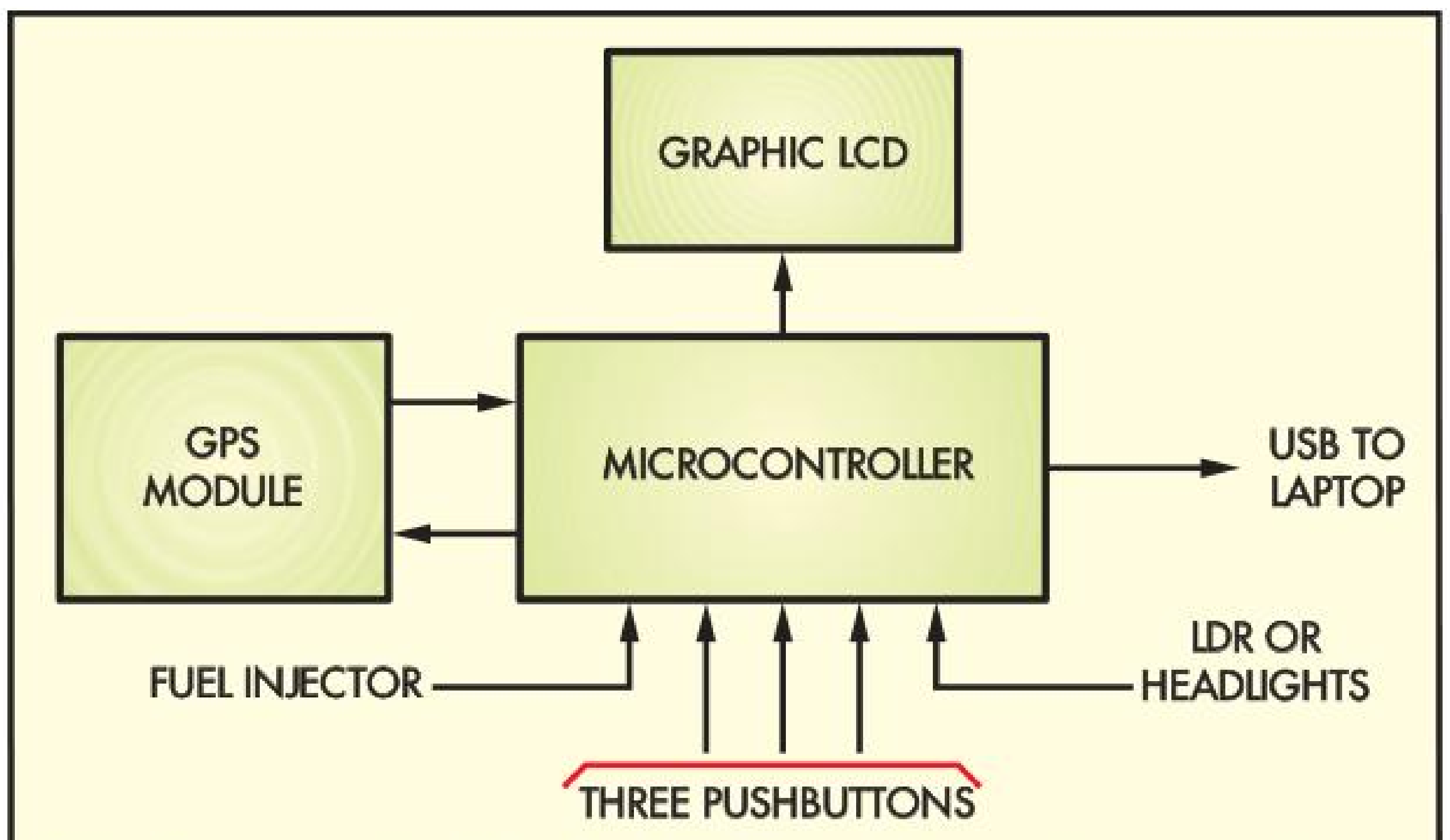


Fig.1: conceptually, the GPS Car Computer is quite simple. The microcontroller takes data from the GPS module, monitors a number of external signals, formats the data for display and sends it to the LCD. While doing this, it can also manage communications with your laptop via USB.

Block diagram

Fig.1 shows a block diagram of the unit. The central item is a 40-pin PIC microcontroller, which does most of the work, including receiving data from the GPS module, driving the LCD and communicating via USB.

The GPS module used is the EM-408, which we have used in a number of previous projects. Once every second, it transmits data such as your current speed, and position as a serial data stream to the microcontroller.

FEATURES:

- Digital speedometer
- Over-speed alarm
- Fuel economy meter
- Distance and time to destination
- Digital clock with GPS accuracy
- Altitude in metres
- Heading and compass
- Current latitude and longitude
- A USB 2.0 interface so that you can use it with your laptop for navigation or uploading firmware changes...

When a complete set of data has been collected, the microcontroller will calculate parameters such as the fuel economy and format the data for display. This data is then sent at high speed to the LCD so that the display updates very quickly – in the blink of an eye!

The microcontroller also monitors a number of inputs, the three pushbutton switches, a light-dependent resistor (or the car's headlights) for night/day detection and a signal from the fuel injector system used in measuring fuel economy. It also controls the backlight brightness of the LCD and communicates over USB to a laptop.

The only other items of note are two voltage regulators, which supply 5V for the microcontroller and 3.3V for the GPS module. The device can be powered from the vehicle 12V battery or from a computer's USB interface.

The main PC board is very small at 123mm × 43mm, and piggybacks onto the LCD readout – the complete display/PC board stack is about 25mm high. The dimensions were deliberately kept small so that the complete unit could be mounted in many places, in addition to sitting on top of the dashboard.

Circuit details

The full circuit diagram of the GPS Car Computer is shown in Fig.3. As discussed before, it is not very complex and is dominated by the microcontroller (IC1), a Microchip PIC18F4550. This is mostly concerned with driving the graphic LCD via an 8-bit bus (D0 to D7) and seven control lines.

The LCD is mounted upside down, so that the data lines are physically on the bottom of the PC board (viewed from the front) and do not short against the GPS module, which must be mounted on top. To accommodate this, the display image is reversed in firmware and the data lines are reversed (D0 on IC1 connects to D7 on the LCD, etc).

An additional output (pin 17 or RC2) is used to control the backlight of the LCD. The microcontroller generates a square wave on this pin, which, via Q1, rapidly switches the backlight LEDs off and on. By varying the duty cycle of this waveform the microcontroller can smoothly control the backlight brightness from off to full on.

Lighting-up time

The firmware allows you to set separate levels of the backlight brightness for day and night, determined by a light sensor or the vehicle headlights. When the microcontroller detects a transition between day and night it will change the brightness gradually over a period of about a minute. This is done so that the driver is not distracted by a sudden change in brightness.

The crystal (X1) on pins 13 and 14 provides the main clock. Within the microcontroller, the 20MHz crystal frequency is divided by five to give 4MHz, and then multiplied by 12 in a phase-locked loop (PLL) to generate the processor clock of 48MHz. This is further divided by four to drive the USB 2.0 interface, and also divided by 4096 to generate an interrupt to the CPU every 85μs.

Continuing in a clockwise direction around the circuit diagram, the three pushbuttons go straight to inputs on the microcontroller, which are pulled high by internal resistors. As a result, a button press causes the input to be pulled low. The firmware switches the pull-up resistors off and on as needed, So, if you use an oscilloscope on these inputs you will not see a simple DC voltage.

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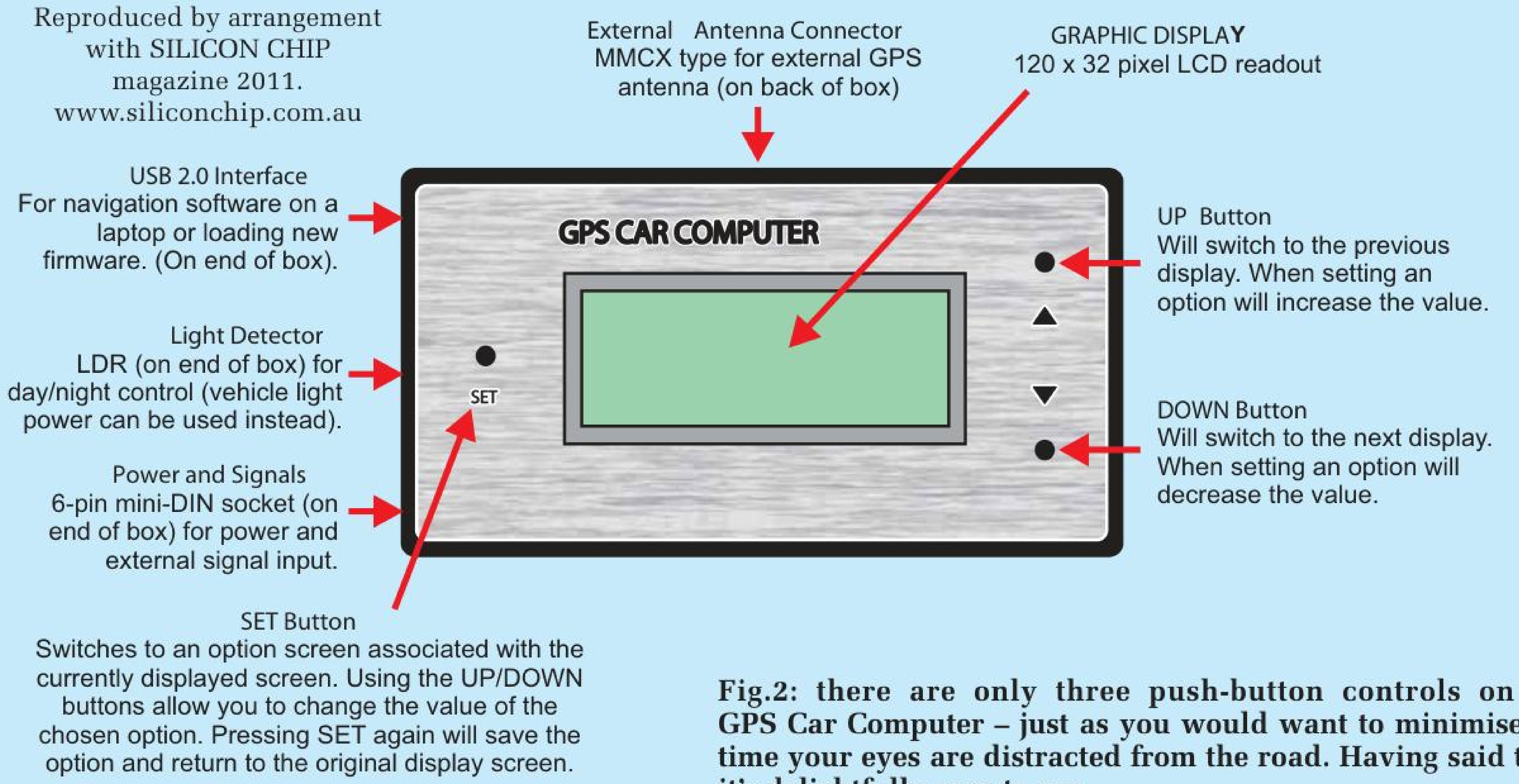

External Antenna Connector
MMCX type for external GPS antenna (on back of box)
GRAPHIC DISPLAY
120 x 32 pixel LCD readout
USB 2.0 Interface
For navigation software on a laptop or loading new firmware. (On end of box).
GPS CAR COMPUTER
UP Button
Will switch to the previous display. When setting an option will increase the value.
Light Detector
LDR (on end of box) for day/night control (vehicle light power can be used instead).
SET
DOWN Button
Will switch to the next display. When setting an option will decrease the value.
Power and Signals
6-pin mini-DIN socket (on end of box) for power and external signal input.
SET Button
Switches to an option screen associated with the currently displayed screen. Using the UP/DOWN buttons allow you to change the value of the chosen option. Pressing SET again will save the option and return to the original display screen.

Fig.2: there are only three push-button controls on the GPS Car Computer – just as you would want to minimise the time your eyes are distracted from the road. Having said that, it's delightfully easy to use.

Pin 18 (Vusb) of IC1 connects to an internal 3.3V regulator, which is used to power the USB interface within the chip. The 220nF capacitor on that pin helps suppress ripple and noise in the regulator.

The data lines (D+ and D–) from the USB socket connect directly to pins 24 and 23 respectively of the microcontroller. This is one of the great features of the Microchip microcontrollers; you do not need external resistors, transceivers or any sort of supporting components. Everything to do with the USB connection is taken care of within the chip.

Jumper JP1 is used to prevent a conflict with the USB power source when the GPS Car Computer is permanently powered from a 12V supply. The need for this is explained in the section on ‘Assembly options’.

GPS module

The interface to the EM-408 GPS module has some tricks to it that need a little explanation. The signal line from IC1’s pin 25 to the module’s receive data input (Rx) is simple enough. The microcontroller runs at over 5V, while the GPS module runs at 3.3V, so the two resistors are necessary to drop the microcontroller’s output voltage to a safe level for the module.

The transmit data (Tx) from the module to the microcontroller is where the problems occur. The voltage level on the

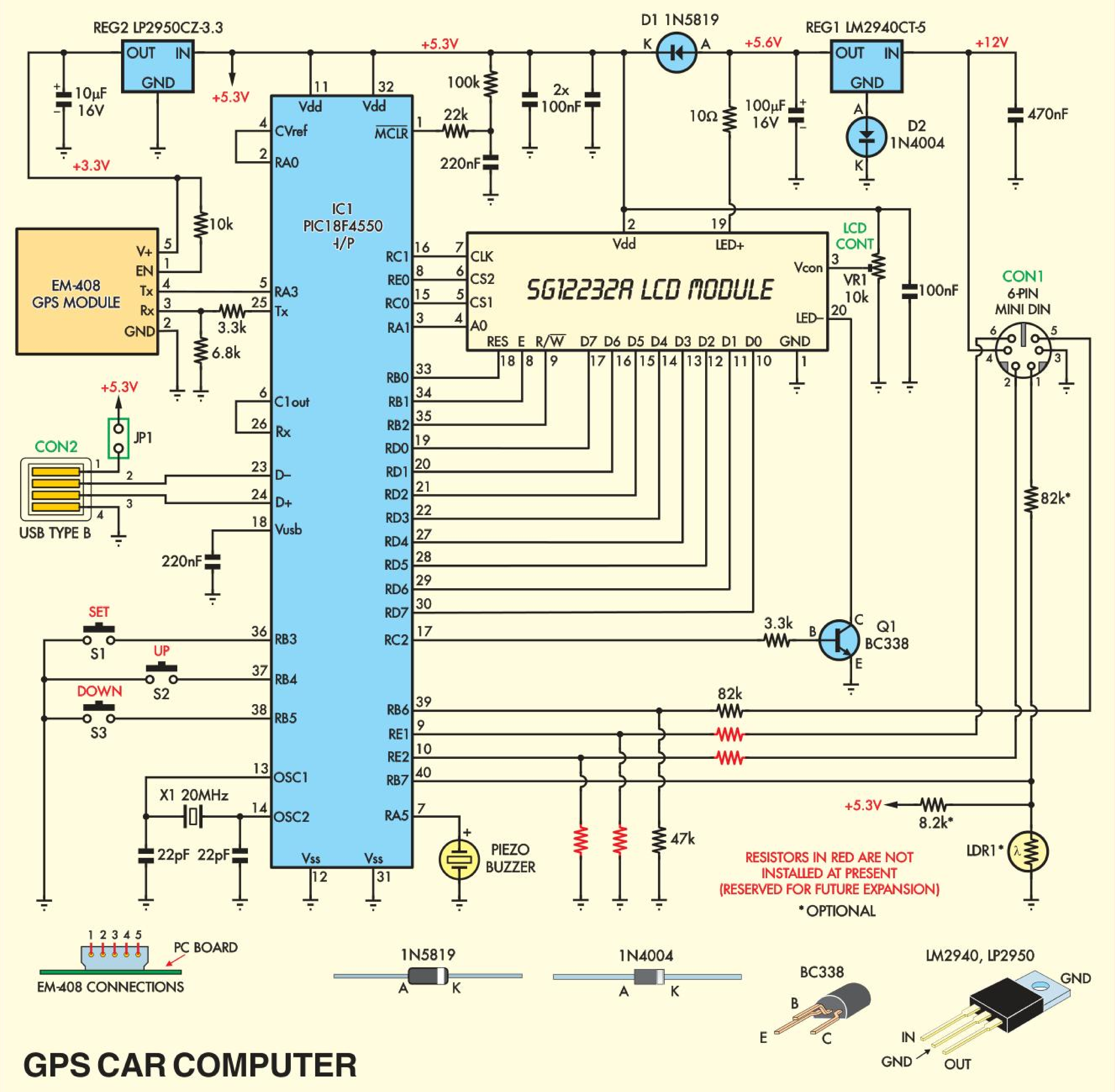

REG2 LP2950CZ-3.3
OUT IN GND
+5.3V
10µF 16V
+3.3V
11 32 Vdd Vdd
100k
22k
MCLR
220nF
2x 100nF
D1 1N5819
K A
+5.6V
REG1 LM2940CT-5
OUT IN GND
+12V
10Ω
100µF 16V
D2 1N4004
470nF
CVref
RA0
IC1 PIC18F4550 -I/P
10k
EM-408 GPS MODULE
V+ EN Tx Rx GND
RA3
Tx
3.3k
6.8k
RC1 RE0 RC0 RA1
CLK CS2 CS1 A0
SG12232A LCD MODULE
Vdd LED+
LCD CONT
Vcon
VR1 10k
LED–
100nF
RES E R/W D7 D6 D5 D4 D3 D2 D1 D0 GND
CON1 6-PIN MINI DIN
RB0 RB1 RB2 RD0 RD1 RD2 RD3 RD4 RD5 RD6 RD7 RC2
C1out
Rx
JP1
CON2
USB TYPE B
D– D+ Vusb
220nF
82k*
SET S1
UP S2
DOWN S3
RB3 RB4 RB5
3.3k
Q1 BC338
B C E
RB6 RE1 RE2 RB7 RA5
82k
OSC1 OSC2
X1 20MHz
22pF 22pF
Vss Vss
PIEZO BUZZER
47k
+5.3V
8.2k*
LDR1*
RESISTORS IN RED ARE NOT INSTALLED AT PRESENT (RESERVED FOR FUTURE EXPANSION)
* OPTIONAL
1 2 3 4 5
PC BOARD
EM-408 CONNECTIONS
1N5819
A K
1N4004
A K
BC338
B E C
LM2940, LP2950
GND IN GND OUT
GPS CAR COMPUTER

Fig.3: the full circuit for the GPS Car Computer. It is dominated by the microcontroller, which is mostly concerned with receiving data from the GPS module and driving the LCD. Other items of note are two regulators, which provide 5.3V and 3.3V.

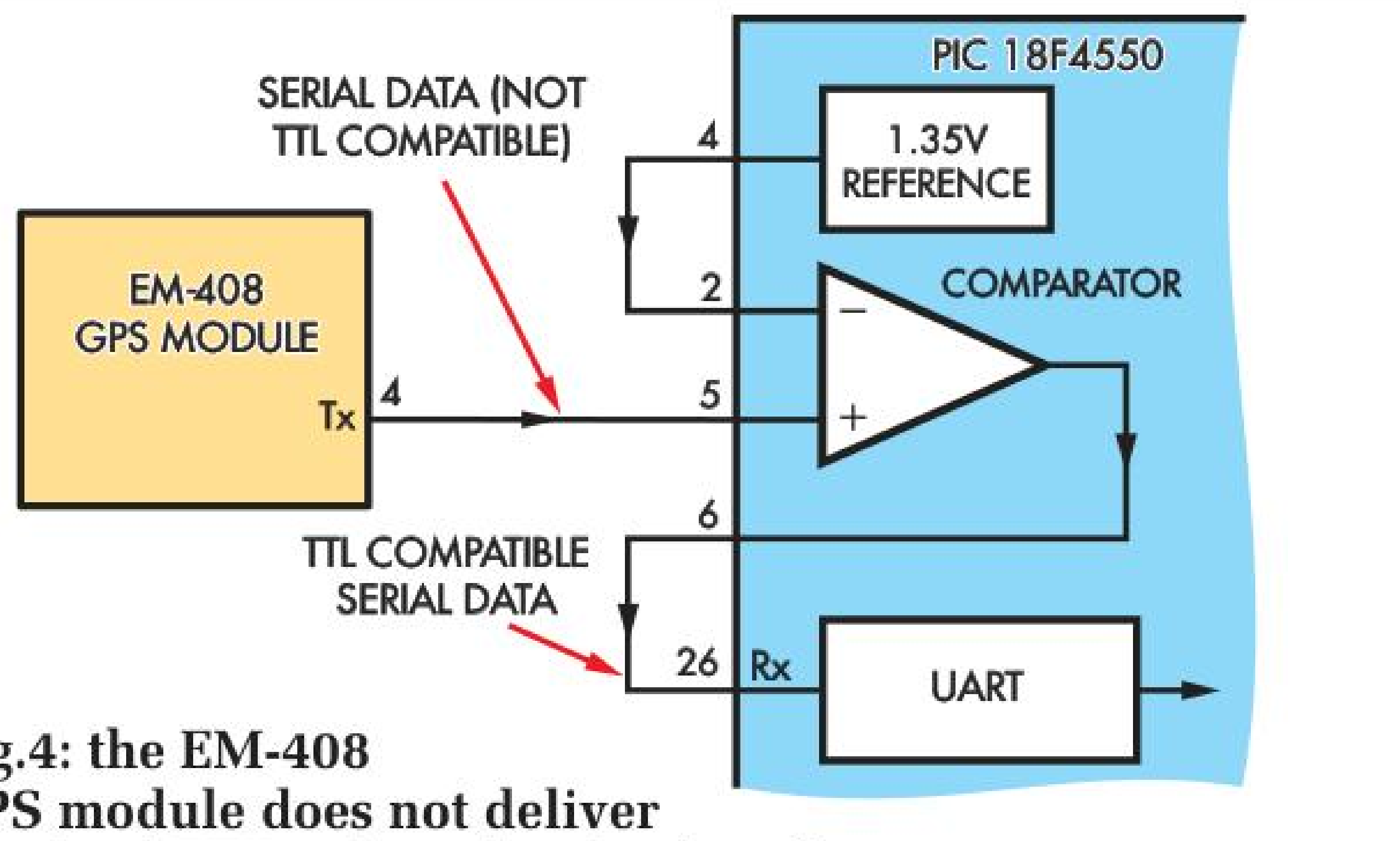


Fig.4: the EM-408 GPS module does not deliver standard TTL voltage levels, therefore, we must convert the signal. This is done by a comparator which compares the signal to a 1.35V reference, both of which are integrated in the microcontroller. The output of the comparator is a TTL compatible signal which is fed to the UART, also within the microcontroller.

EM-408's transmit line is a little lower than the standard TTL threshold for a high logic level.

This, coupled with noise and temperature variations will cause intermittent errors in the data stream, as read by the microcontroller.

If you refer to Fig.4, you can see that we overcome this issue by feeding the transmit data to the non-inverting input of an analogue comparator circuit within the microcontroller (pin 5 or RA3). The microcontroller is also set up to generate a 1.35V reference voltage, which is available on pin 4 (CVref). This in turn is connected to the inverting input of the comparator on pin 2 (RA0).

The result is that the transmit data signal from the EM-408 is compared to 1.35V and the clean, TTL-compatible, output is available on pin 6 (C1out), which is connected to the input to the serial data receiver (UART) at pin 26 (Rx).

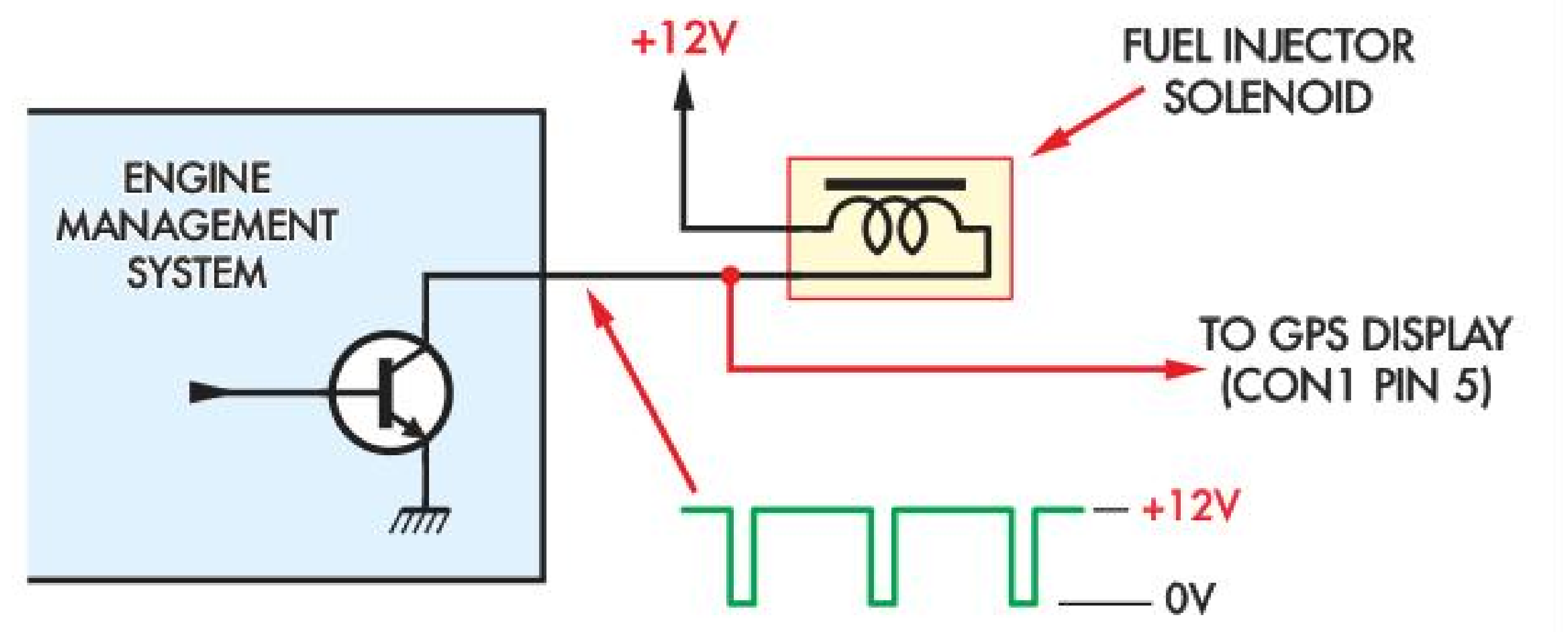


Fig.5: a simplified diagram of the fuel injector control in a standard petrol engine. The positive lead of the injector is at 12V and the engine management pulls the negative lead to zero potential to open the solenoid and inject fuel into the inlet manifold. It is this signal that you should feed to the GPS Car Computer.

Power supply

The main power is derived from the vehicle's 12V battery, present at pin 4 of the DIN input/output connector (CON1). REG1 is a 5V linear voltage regulator designed for automotive use, so it can withstand large voltage spikes, momentay reversal of the input voltage and other abuses that are common in the auto environment.

If the backlight turned on full, the regulator will dissipate almost 1W, so it is mounted on a small heatsink.

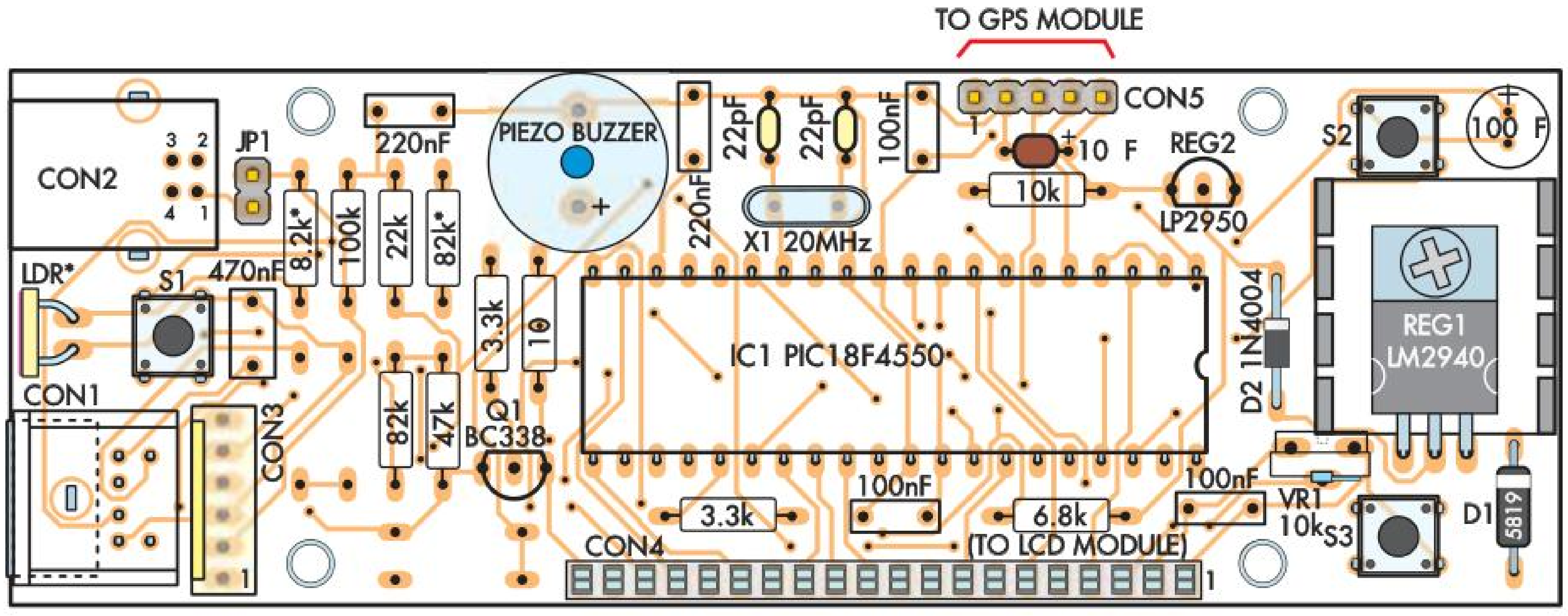
Silicon diode D2 in the common leg of the regulator serves to raise its output to 5.6V, then the 1N5819 Schottky diode in series with the output (D1) will drop about 0.3V, resulting in an output of about 5.3V for the LCD and microcontroller.

This is done for a number of reasons. First, diode D1 serves to isolate the main power supply if the GPS Car Computer Display is plugged into a USB port. If D1 was not present, the 5V supply from the USB port would also try to drive the output pin of the voltage regulator, resulting in excessive current from the USB source.

The second feature of this circuit is that it provides a 5.3V supply to the LCD. This is needed because the contrast of the LCD is controlled by the voltage on pin 3 (Vcon) with reference to the voltage on pin 2 (Vdd). For normal contrast,

The GPS Car Computer mounts on the UB3-size plastic box lid, which becomes the base . . . with the LCD readout showing through a cutout in the base . . . which becomes the front panel.

Fig.6: component overlay for the main PC board. Components marked with an asterisk (*) are optional – their use is explained in the text. The GPS module 'plugs into' the header socket, CON5, while the LCD readout module plugs into the longer socket, CON4.



the voltage on pin 3 should be about –4.9V to –5.1V compared to pin 2, although this varies with temperature and manufacturing tolerances.

Without going into the subtle details, this means that either the supply voltage on pin 2 of the LCD must be noticeably higher than 5.1V, or we must be prepared to supply a negative voltage to pin 3 to get a proper level of contrast. Our approach of using D1 and D2 to give 5.3V is much simpler than generating a negative voltage.

The final benefit of this power supply design is that we can use the 5.6V (via a 10Ω current-limiting resistor) for driving the backlight LEDs. Given the various voltage drops involved (about 3.6V across the LEDs and 0.7V across Q1) it is much easier to get full brightness from a supply that is a bit higher than 5V.

This arrangement also means that the backlight is automatically disabled when a USB power source is used – handy, because the USB interface on your computer would be overloaded if the backlight was enabled.

The second voltage regulator, REG2, is a 3.3V device that supplies the GPS module. It has a low dropout voltage, so it is happy with the 2V voltage differential between its input and output, and it comes in a TO92 package, which is convenient, as there is not much space on our PC board.

External connections

All external connections are made through CON1, a 6-pin mini DIN connector. Ground and +12V are on pin 3 and pin 4 of the connector. An external input from the vehicle's headlight's circuit can be wired to pin 1 to control the day/night backlight brightness (more on this in the section on 'Assembly options').

Pin 5 of (CON1) can be wired to a fuel injector solenoid if you want to implement the fuel economy meter function. The 82kΩ and 47kΩ resistors serve to drop the vehicle voltage levels to 5V for the microcontroller (IC1).

There are also two spare connections (pins 6 and 2) which can be connected to pins 9 and 10 of the microcontroller. They are unused and available for future use. They can be set by the firmware to be digital inputs or outputs, or analogue inputs.

Future firmware updates could use these to measure voltages (eg, battery voltage or sensor outputs), detect digital inputs (eg, switch closure or tachometer output) or set them to be an output to control something.

Software

All software program files for the *GPS Car Computer* will be available from the *EPE* website at: **www.epemag.com**.

PC board

The GPS Car Computer is built on a single PC board, it is double-sided and uses plated-through holes, thereby maintaining the small size. The PCBs for this project are only available with the kit from Altronics (**www.altronics.com.au**). However, the PCB files will be downloadable, in Eagle CAD format, from the *EPE* website (**www.epemag.com**) for constructors who wish to build their own boards. Given the fact that it is a double-sided board with plated-through holes, home fabrication is a lot more difficult than standard (single-sided) boards.

This type of PC board is actually easier to assemble than the single-sided version commonly used. This is because the board is coated in a varnish (called solder resist) which protects tracks and areas that should not be soldered. It also has the position and values of the components printed on the top side of the board, which means that assembly is mostly an exercise in following the diagrams.

When soldering this type of board, you should observe normal good soldering practice. Use a temperature controlled iron set to about 360°C with a fine tip (0.8mm chisel is good). Use fine, resin-cored solder (0.8mm or less) and don't hold the iron on a joint for more than three or four seconds.

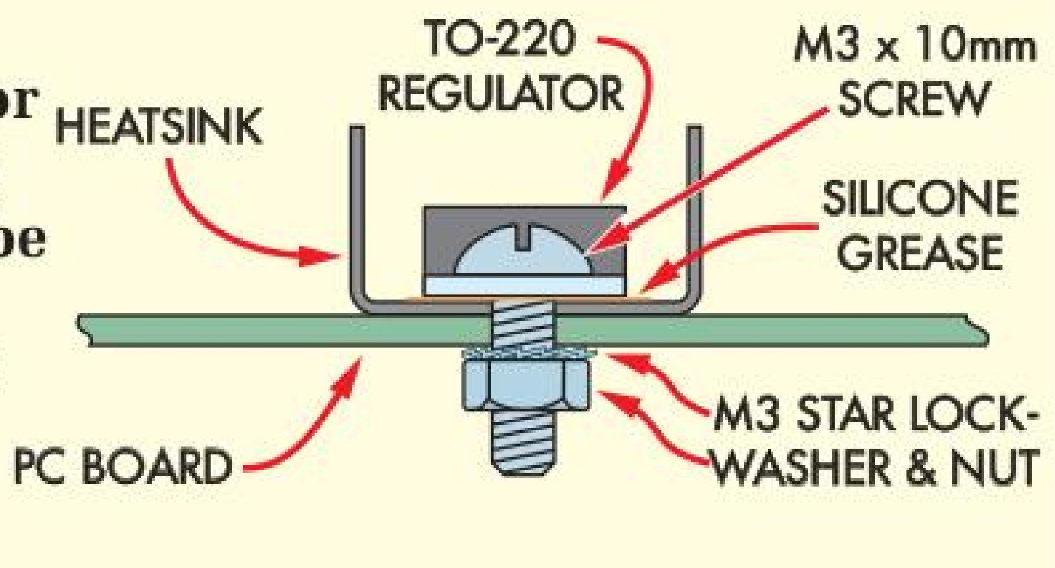
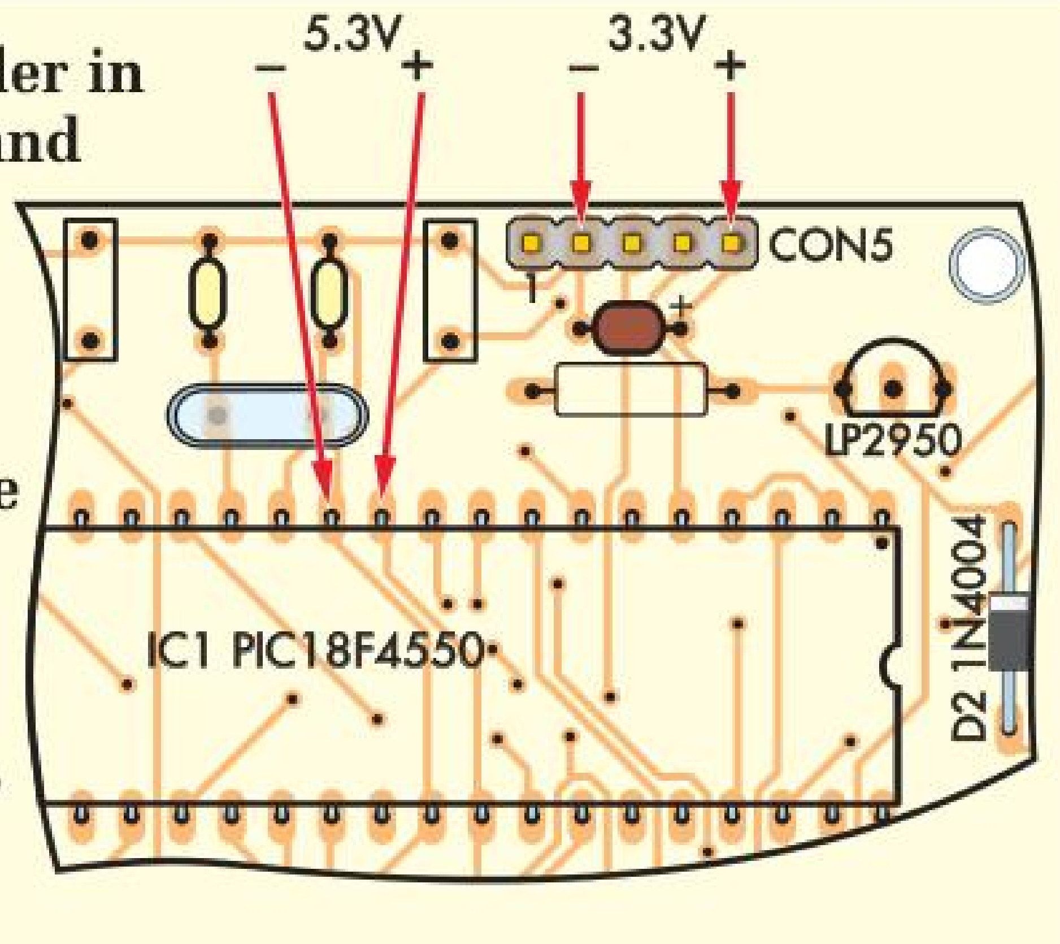
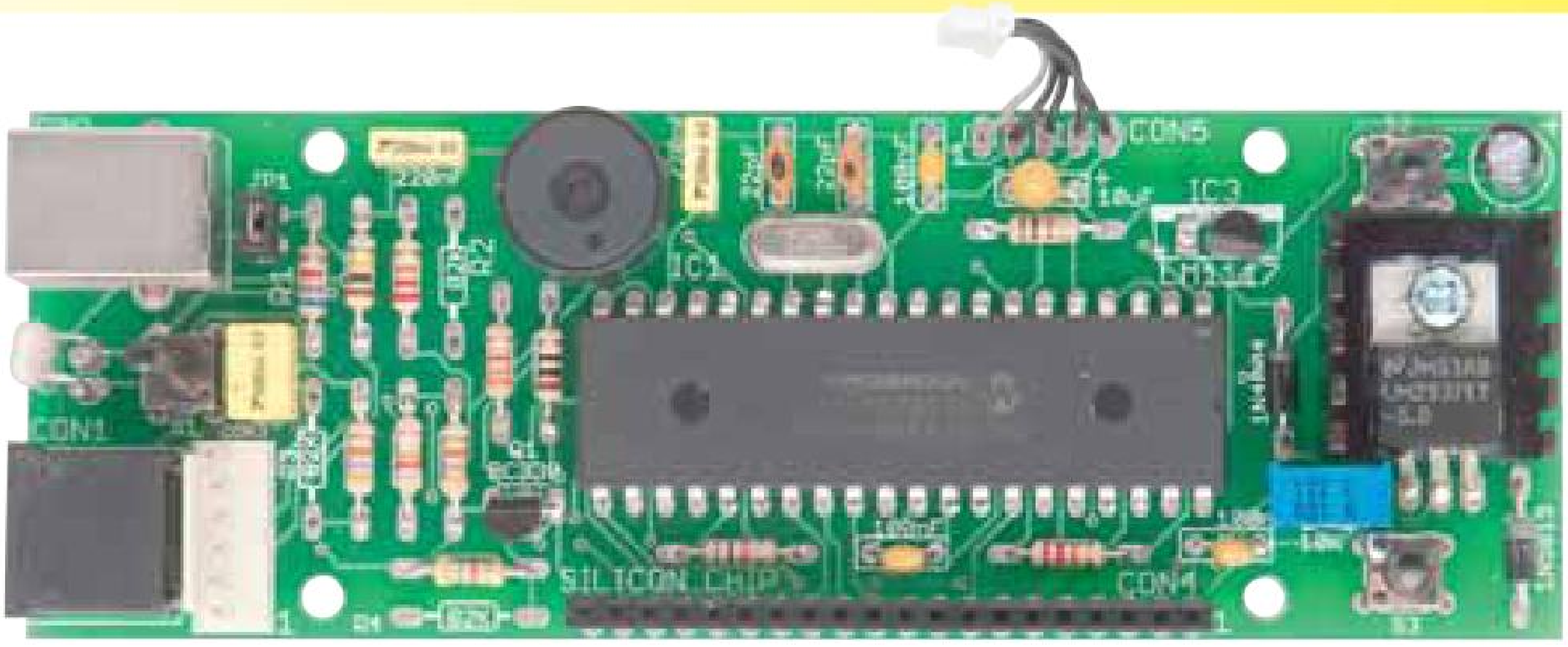


Fig.7: the 5V regulator (REG1) can dissipate up to 1W, so it *must* be mounted on a heatsink. A smear of heat transfer compound must be applied between the regulator and the heatsink. Before tightening the bolt check that the heatsink clears the nearby solder pads. Only after you have tightened the nut and bolt should you solder the regulator's leads to the PC board.

Fig.8: before you solder in the microcontroller and connect the GPS module you should check that these voltages are present. Both have a tolerance of ±150mV. If you cannot measure the correct voltages you should check D1, D2, IC2, IC3 and the power connection.





Here's a photo of the GPS Car Computer to match the overlay at left. In this case, the LDR option is used to control the day/night function – this is an early prototype.

The use of plated-through holes means that you don't need to install links, but it does mean that it is difficult to remove a component after it has been soldered in. So, take extra care before you apply the soldering iron – check that the component is the right value and oriented correctly.

The best way to remove a component from a board with plated through holes is to cut its leads close to the body, then pull the leads out with pliers while applying heat to the solder pad. You can then use de-soldering braid or a solder sucker to remove the excess solder from the pad and hole.

Assembly options

Before you start soldering, there are a few assembly options that you need to consider.

The first is the control of the backlight brightness. The microcontroller (IC1) determines if it is day or night by the voltage on pin 40 (RB7). When it is above about 1.4V it is night; less than that, it is daytime.

By rearranging the components on this input you can use a light-dependent resistor (LDR) or the car's headlight circuit to switch between the night and day brightness levels. The following table lists the components used:

	LDR Control	Headlight Control
LDR	Install LDR	47kΩ resistor
R1	8.2kΩ resistor	Leave empty
R2	Leave Empty	82kΩ resistor

Note that for headlight control, the 47kΩ resistor is installed vertically in the position marked for the LDR.

You also need to decide how you will wire up the power and other leads going to the mini DIN plug. If you are installing the GPS Car Computer permanently, you should connect the negative to the chassis and the positive power lead to a spare position in the fuse panel (if there is one) with a 500mA fuse.

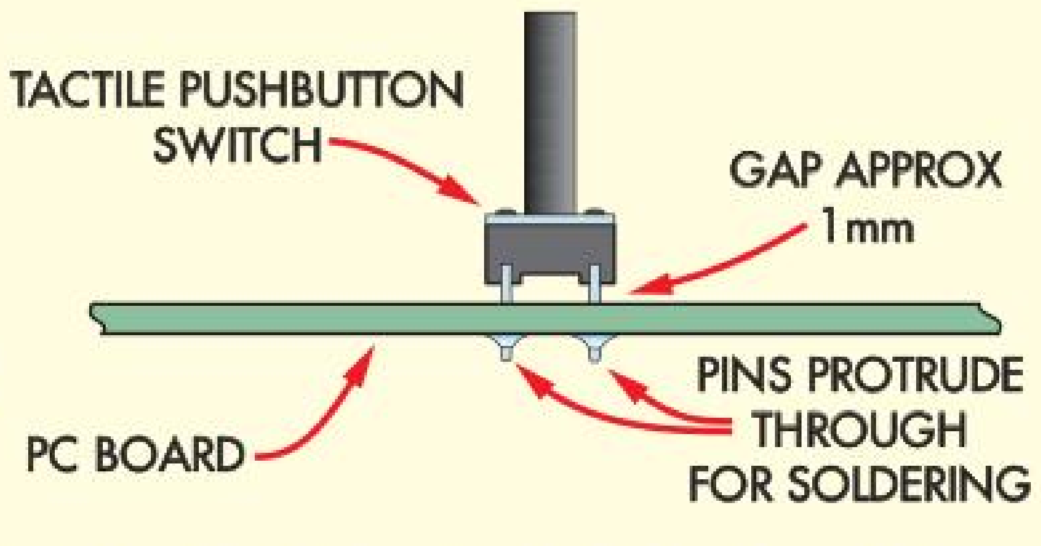

TACTILE PUSHBUTTON SWITCH
GAP APPROX 1mm
PC BOARD
PINS PROTRUDE THROUGH FOR SOLDERING

Fig.9: the tactile switches must sit 1mm above the PC board so that the actuating rod will protrude far enough through the front panel. This spacing is achieved by making sure that the switch leads only protrude by a fraction of a millimetre on the underside of the PC board.

It may be easier to connect to a permanent 12V source and wire via an in-line 3AG fuseholder with fuse.

Refer to the Features Panel later in this article for the connection of power and other signals to the DIN connector. If you have decided on headlight brightness control you should wire pin 1 of the DIN connector to the vehicle wiring, so that the voltage is at 12V when the headlights are turned on.

A connection between pin 5 and a fuel injector is also necessary if you want to use the fuel economy feature. Fig.5 shows a typical circuit used in a modern car. You need to locate a negative solenoid lead and connect to that.

The crude method would be to pierce the insulation of the wiring at the solenoid in the engine bay. This would expose the wire to corrosion and other dangers.

A more elegant and reliable method would be to locate the engine management unit, normally behind the firewall in the passenger compartment, and connect to the appropriate lead there.

If you need to move the GPS Car Computer around, the best approach would be to wire the power leads to a cigarette lighter-style plug, with the positive power lead connected to the tip and the negative lead to the side wings. Most of these connectors have a fuse in the body of the connector, but if not, you should insert an in-line fuseholder fitted with a 500mA fuse.

Another option for you to consider is jumper JP1, which is used to isolate the USB 5V supply. Normally,

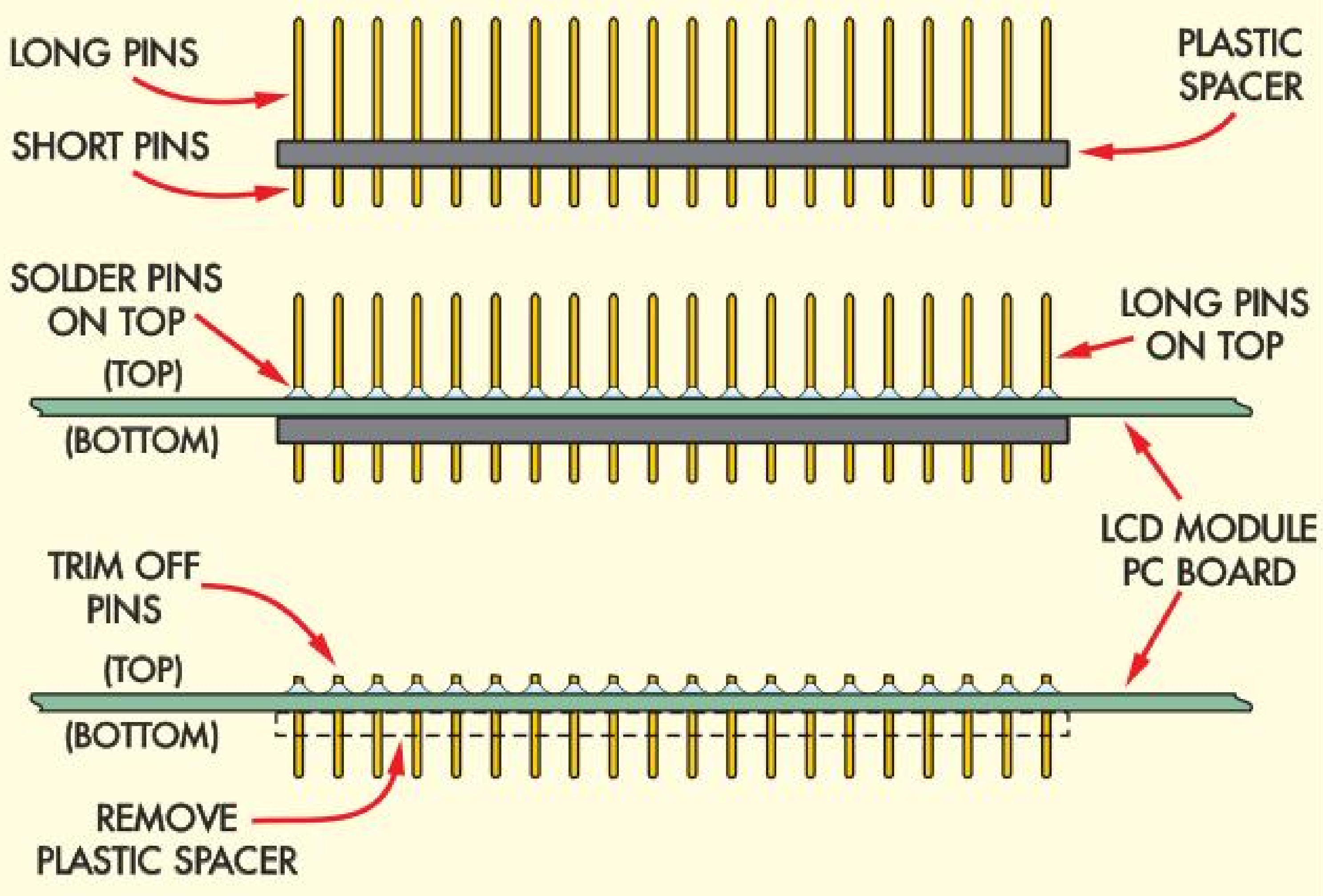
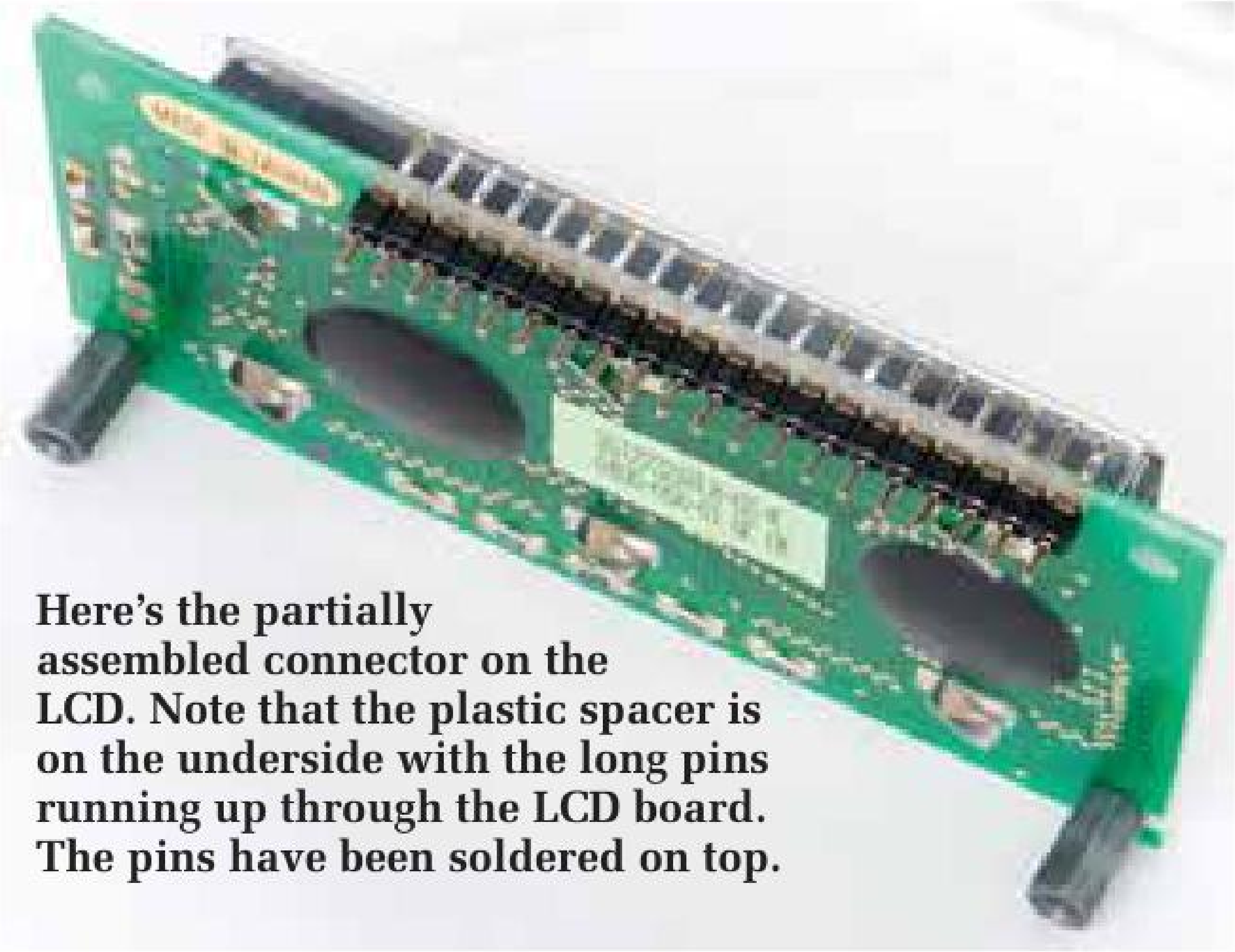


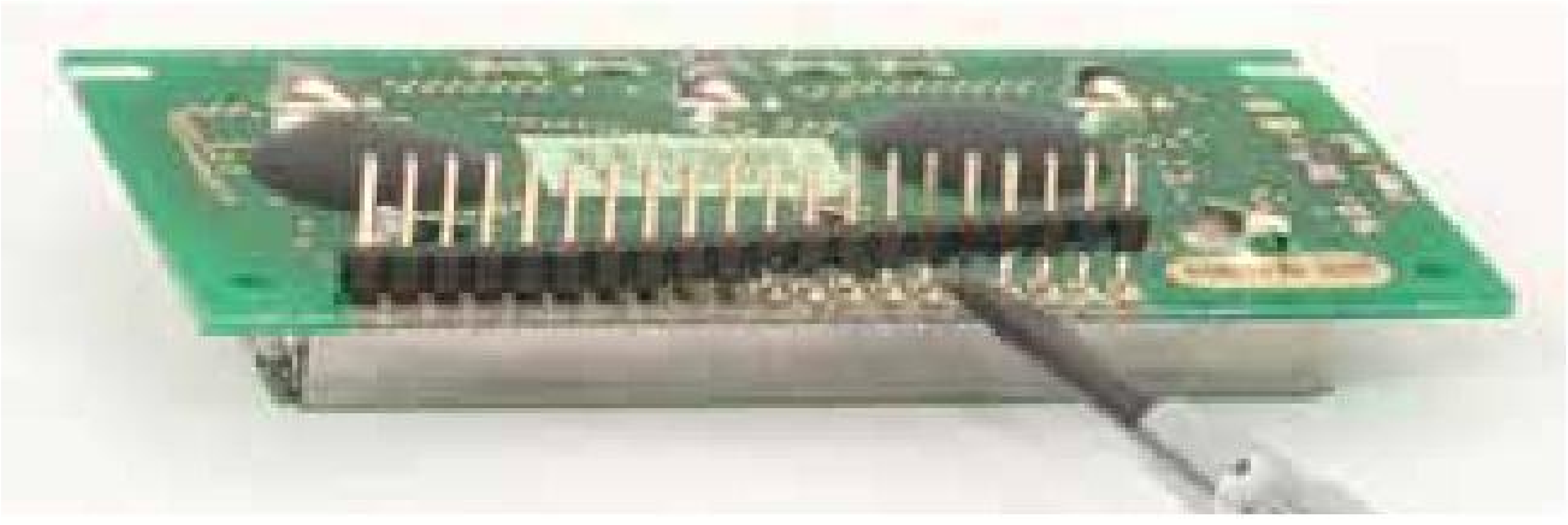
Fig.10: the LCD has 20 pins which plug into the socket on the main PC board. Insert the long pins of the pin header from the underside of the display so that the plastic spacer is flush with the underside. Solder the pins on the top, lever off the plastic spacer and trim the pins on the top of the LCD board.



Here's the partially assembled connector on the LCD. Note that the plastic spacer is on the underside with the long pins running up through the LCD board. The pins have been soldered on top.

this is left in place so that you can power the unit from either USB or 12V sources. You cannot use both simultaneously, as this would place 5.3V from the GPS Car Computer on the USB 5V line from your computer, possibly causing damage.

However, in some cases you might want to permanently wire the unit to 12V, but still need to connect it to a computer via USB. To cover this eventuality, JP1 is provided. When the jumper is removed, the USB cannot power the device, thereby removing any possible conflict.



This photo shows how to remove the plastic spacer on the underside of the display board using a small screwdriver. You must remove the spacer so that the LCD can snugly mate with the main PC board. The pins on top of the board have already been trimmed. (Refer also to Fig.10).

Construction

Start assembly by soldering the 20-pin socket for the LCD to the PC board. Ensure that it sits fully flush with the PC board before you start soldering.

The reason for starting with this socket is that it allows you to temporarily place the LCD display on top of this socket while positioning the other components.

This is important, as there is limited clearance (6 to 8mm) between the main PC board and the underside of the LCD display, and you need to be sure that the components on the main PC board do not foul the LCD board before you solder them in.

This particularly applies to the buzzer and trimpot, both of which tend to have extra plastic on their underside. You should cut this away with a sharp knife and make sure that

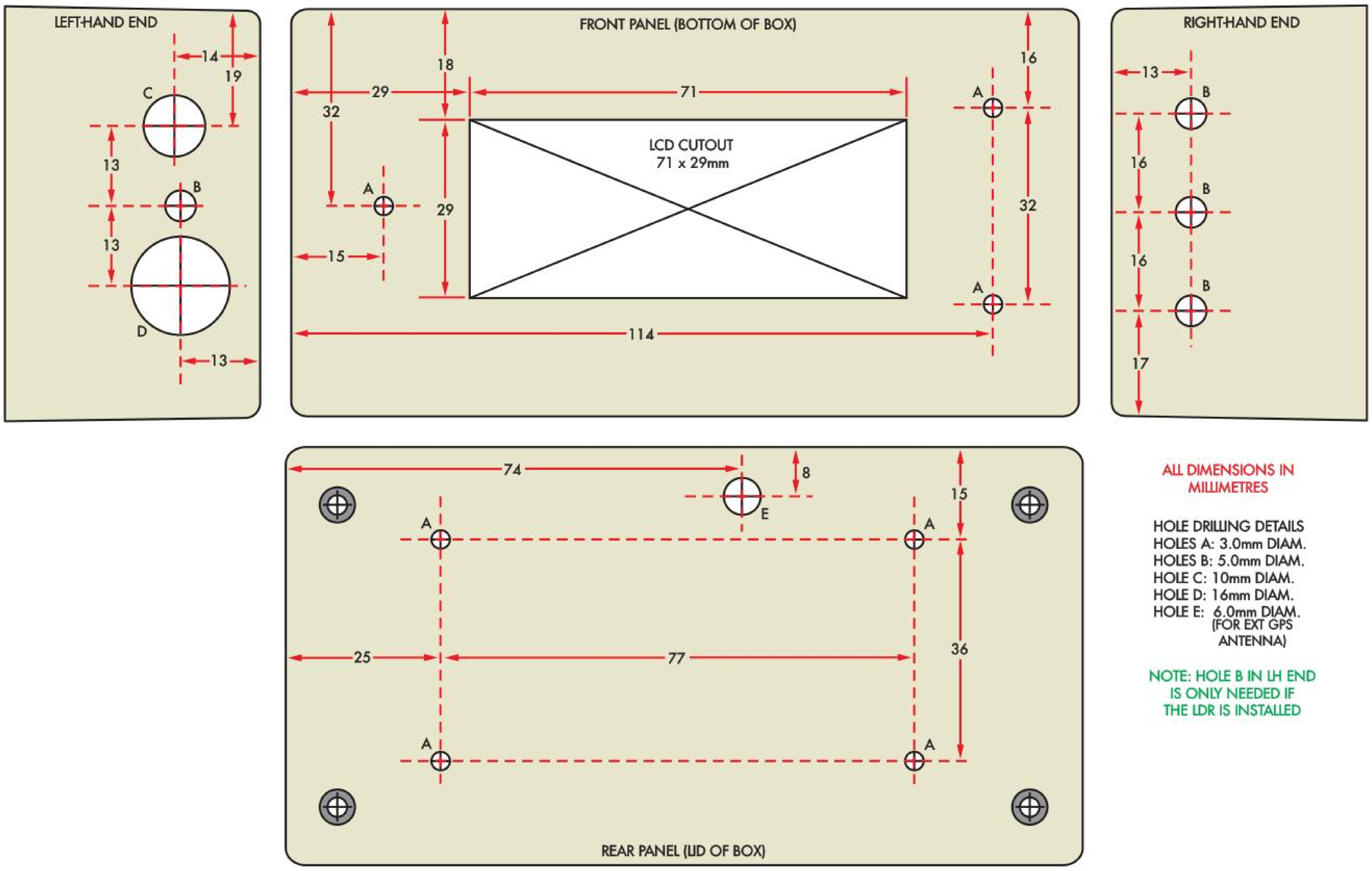

LEFT-HAND END
14
19
C
13
B
13
D
13
FRONT PANEL (BOTTOM OF BOX)
18
29
71
32
A
LCD CUTOUT
71 x 29mm
29
15
114
16
A
32
A
RIGHT-HAND END
13
B
16
B
16
B
17
74
8
E
15
A
A
25
77
36
A
A
REAR PANEL (LID OF BOX)
ALL DIMENSIONS IN MILLIMETRES
HOLE DRILLING DETAILS
HOLES A: 3.0mm DIAM.
HOLES B: 5.0mm DIAM.
HOLE C: 10mm DIAM.
HOLE D: 16mm DIAM.
HOLE E: 6.0mm DIAM. (FOR EXT GPS ANTENNA)
NOTE: HOLE B IN LH END IS ONLY NEEDED IF THE LDR IS INSTALLED

Fig.12: the drill holes and cutout required for the front panel, left and right ends and the box lid (which becomes the base). This diagram is reproduced at 80% – photocopy at 125% so that it can be used as a template. The centre hole in the left-hand end is only necessary if the LDR is installed. The holes in the right-hand end provide ventilation for the 5V regulator – accuracy is not so important in positioning these holes.

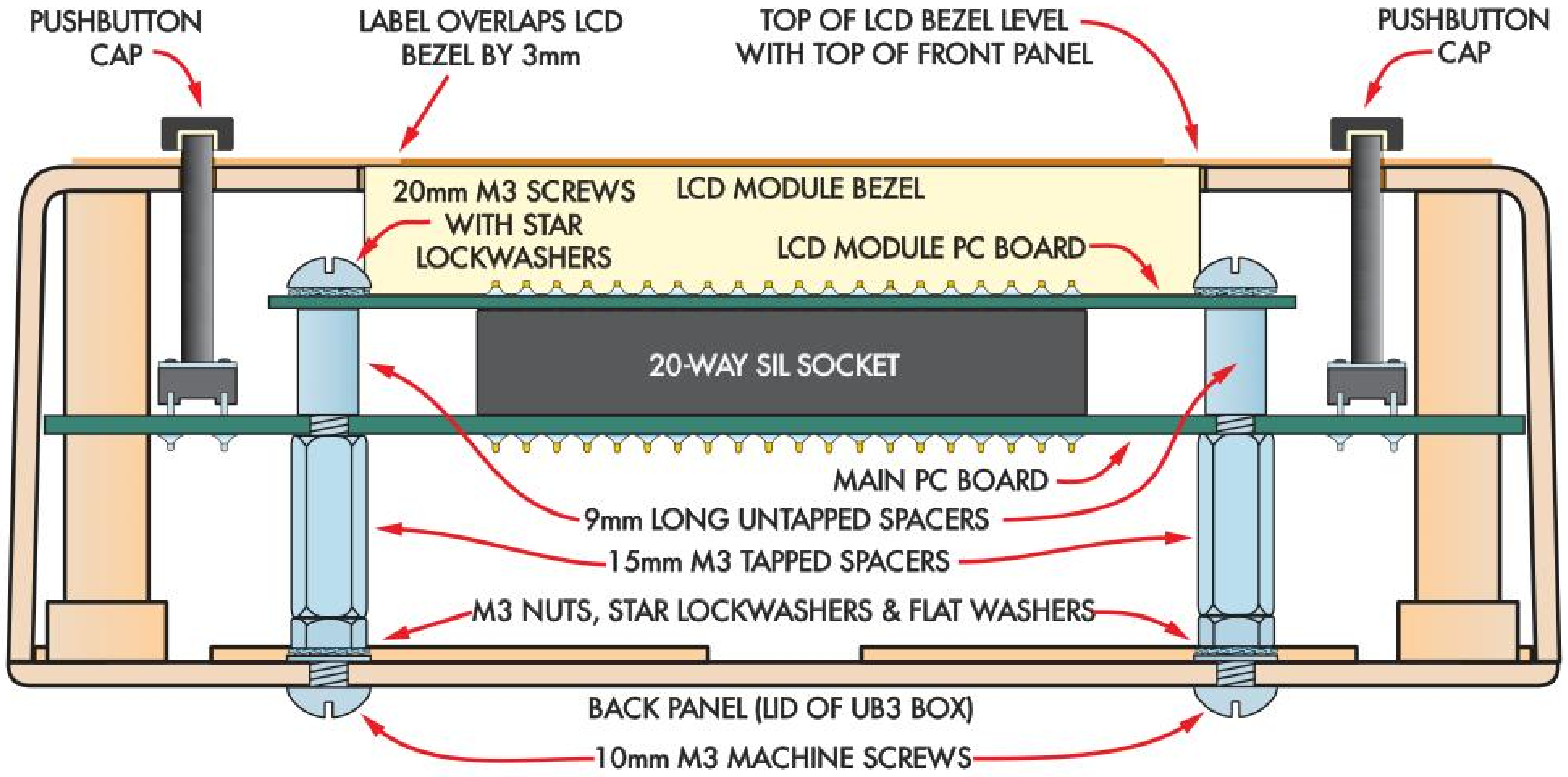

PUSHBUTTON CAP
LABEL OVERLAPS LCD BEZEL BY 3mm
TOP OF LCD BEZEL LEVEL WITH TOP OF FRONT PANEL
PUSHBUTTON CAP
20mm M3 SCREWS WITH STAR LOCKWASHERS
LCD MODULE BEZEL
LCD MODULE PC BOARD
20-WAY SIL SOCKET
MAIN PC BOARD
9mm LONG UNTAPPED SPACERS
15mm M3 TAPPED SPACERS
M3 NUTS, STAR LOCKWASHERS & FLAT WASHERS
BACK PANEL (LID OF UB3 BOX)
10mm M3 MACHINE SCREWS

Fig.11: this shows how the main PC board and LCD are joined together and mounted in the UB3-size box. It is important that the actuators of the tactile switches protrude far enough that the caps will fit without touching the front panel. It is also important that the LCD bezel is flush with the outside surface of the front panel.

the body of the component sits flush on the PC board and the top clears the LCD above.

Other components that you need to watch out for include the transistor (Q1), the 3.3V regulator (REG2) and the 10μF capacitor. For now, continue with the low profile components, such as resistors and diodes and then move on to the taller components. At this stage, do not solder in the microcontroller or the pushbutton switches.

Note that resistors R3, R4, R5 and R6 are marked on the PC board but not installed, as they are reserved for future expansion. Be careful with D1 and D2 as they look alike. The same applies to Q1 (the transistor) and REG1 (the regulator), both are in TO-92 packages and can easily be confused.

When soldering in the crystal (X1) ensure that it sits a millimetre or two above the PC board so that there is no danger of the metal case shorting the connecting pads underneath.

The LM2940 regulator (REG1) sits on top of a small heatsink, as shown in Fig 7. Refer to this diagram for assembly instructions. Before screwing down the regulator, check that the heatsink does not touch the solder pads on either side of the heatsink. The spacing is very close here, but the heatsink can be slid around to ensure that it has adequate clearance.

Once this is correct, you can tighten the nut and bolt. Finally, solder the regulator's leads – this is left to last so that the solder joint is not stressed.

The PC board has provision for an extra connector (CON3) which also can be seen in photographs of the prototype. Ignore this, as it is intended for use with an In Circuit Debugger used only during software development.

Quick test

With all components in place (except the microcontroller, switches, GPS and LCD) we can make a quick test to ensure that the voltages are correct.

With the power/signal cable plugged into the mini DIN socket and the power turned on, you should be able to measure about 5.3V between pins 11 and 12 of the microcontroller. Between pin 2 and pin 5 of the GPS connector (CON5) you should be able to measure 3.3V. Both could vary by ±150mV.

Refer to Fig.8 for the measurement points. If you cannot measure the correct voltages you should check diodes D1, D2, regulators REG1, REG2 and the power connection.

Final PC board assembly

It's time now to install the microcontroller, IC1. This must be first programmed with the required program file (available for download from the *EPE* website) using a normal PIC programmer.

When handling the microcontroller and LCD you should take the standard precautions against electrostatic discharge (ESD), which could zap these devices. This means making sure that your work surface, your soldering iron and *you* are all grounded.

As there is not enough clearance between the PC board and the LCD for an IC socket, the microcontroller must be soldered directly to the PC board. Normally, you would need to remove it for reprogramming, but as you can upload new firmware by USB, this is not a concern.

However, once you have soldered the microcontroller you will not be able to remove it without destroying it. So, please read the next two paragraphs carefully.

Pin 1 of the microcontroller is clearly marked on the PC board and is the top right-hand pin when the PC board is

Loading New Firmware

The GPS Display includes the facility to reprogram itself over the USB, this is sometimes called 'flashing'. You don't need any programming hardware and it uses free software. Full instructions will be included with any updates, but the following will give you the flavour of how it works.

To place the device into programming mode you hold down the Set button while you plug it into a USB port on your computer.

This causes the GPS Display to masquerade as a Microchip PICDEM FS USB board and, as far as your computer is concerned, this is exactly what it is. This small deception allows us to use software developed by Microchip to upload new firmware to their own products – much easier than developing our own.

Your computer will then ask for a device driver for the PICDEM board. This is different from the virtual serial port driver used to receive GPS data from the GPS Display, and will be included with any updates or can be downloaded from the Microchip website.

When the device driver has finished loading you can run the programming software provided by Microchip for their PICDEM FS USB board. This allows you to load the HEX file and reprogram the device, which takes only 20 seconds or so. You then unplug the USB cable and when you restart your GPS Display it will be running the new firmware.

You don't have to worry about a power failure or accidently unplugging something while it is programming. The programming code will not be affected if something does go wrong, so you can always restart and try again or reload your original firmware.

viewed from the front. This must be matched to the dimple marking pin 1 on the IC's body. This means the microcontroller is installed upside down compared to the other components and the silk screen printing on the board.

Before you apply the soldering iron, make sure that the part number printed on the chip is inverted compared to the printing on the PC board.

We understand that Altronics will be producing a kit with a machine cut front panel which will make construction much easier. This will also allow each button cap to sit within a hole in the front panel and consequently there will be more space between the LCD and PC board. The main advantage of this is that an IC socket (supplied with the kit) can be used for IC1 and you do not need to panic over permanently soldering it in.

Pushbutton switches

When you have finished with the microcontroller you can install the three pushbutton switches. These have been left to last because they can be easily damaged if the actuating rod is accidently forced too far to the side during assembly of the board.

As illustrated in Fig.9, the body of the switches must sit 1mm above the PC board. This is necessary so that the actuating rod will protrude far enough through the front panel. This spacing is easily achieved by making sure that the switch leads only protrude by a fraction of a millimetre on the underside of the PC board before soldering.

The next assembly step is the connecting pins on the LCD. Start by inserting the long pins of the 20-way pin header strip through the matching holes on the LCD from the bottom. The plastic spacer should be flush on the underside of the display's PC board and the shorter pins underneath. See Fig 10.

Solder the pins on the top of the board while ensuring that the spacer underneath remains flush with the board. Then remove the plastic spacer, leaving just the pins. This is best done with a fine screwdriver – lever down one end of the spacer by a few millimetres, then the other end followed by the middle. After repeating this a few times the plastic spacer will slide off the pins.

The GPS module is supplied with a cable with identical connectors on each end. Cut off one of the connectors, bare

GPS Car Computer – Features Summary

Automatic Scan

Simultaneously pressing both the Up and Down buttons will set auto scan. In this mode, the unit will step to the next screen every three seconds. Pressing either Up or Down will terminate auto scan.

The data displayed can be configured as described below.

Show/Hide Display Screens

Holding down the Up button while applying power will enter a special mode to configure what screens will be displayed or hidden.

Repeatedly pressing Set will select:

- Show (ie, the screen will always be displayed).
- Hidden when Auto Scan is operating, otherwise shown.
- Hidden Always. This is useful if, for example, the Fuel Economy Meter is not being used – it can then be hidden to reduce the visual clutter.

Press Up or Down to move to the next screen to be configured. Remove power to exit this mode.

USB 2.0 Interface

The GPS Display creates a virtual serial port over USB, and you can use this to connect to your laptop to show the GPS output, plot your location on moving maps and other functions using free and paid software.

You must load the Serial Device Driver on to your PC.

Firmware Updates

By holding down the Set button when plugging into a USB port the GPS Display will accept firmware updates delivered via USB. Programming hardware is not required.

Low Signal

In a low signal situation or when first turned on, the GPS Display will display a message and a count of the number of satellites found at that time.

Pressing the Set button will show the Current Signal Levels screen described on the next page.

Full Reset

Pressing the Down button for a couple of seconds while applying power will reset the GPS module and all configurable parameters to the factory/design defaults.

Automatic Brightness Control

The brightness of the LCD backlight can be configured separately for day and night. Control of day/night can be from the vehicle headlights, or from a light-dependent resistor (LDR).

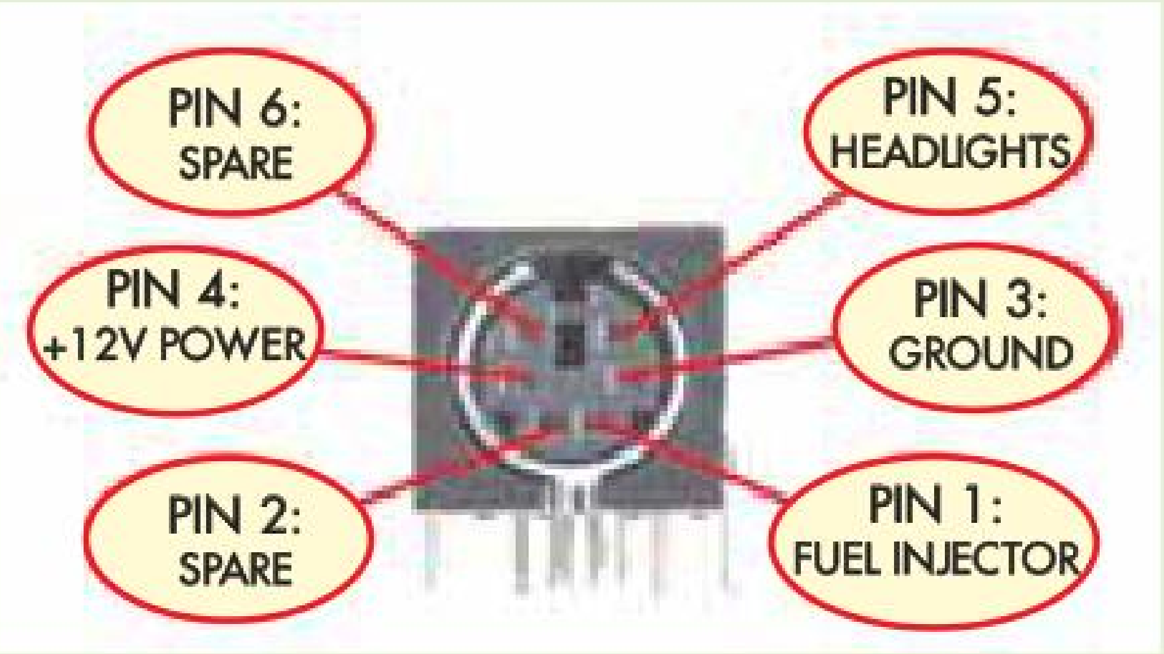
When switching from day and night the brightness is slowly changed over a minute or so to avoid distracting the driver.

Power, Signal Connector

Pin 3 is ground

Pin 4 is +12V power input

Pin 5 is the fuel injector input. Connect to the negative wire of a fuel injector (this is pulled to ground when the injector solenoid is activated).



Pin 1 is the vehicle headlights input. It will control the day/night brightness of the backlight. This input is optional and is disabled if a light-dependent resistor is used.

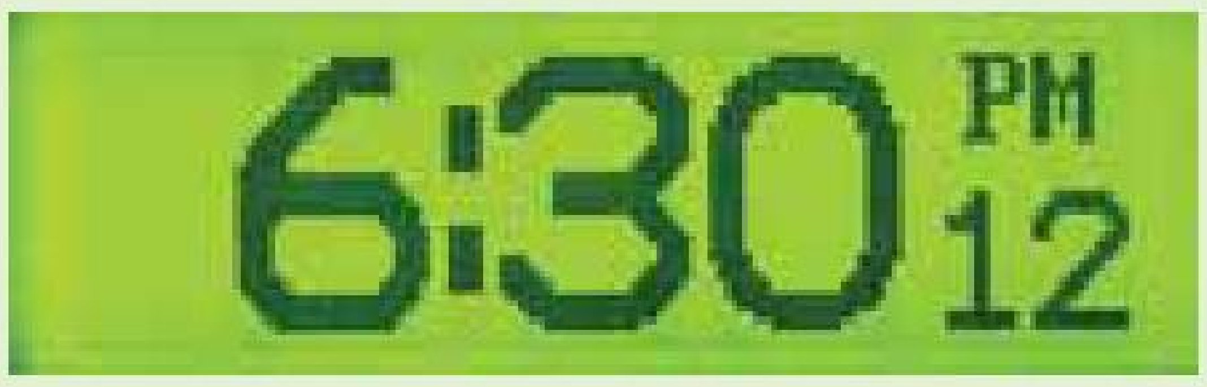
Pin 2 and pin 6 are spare input/output lines for future enhancement. In this version they are left unconnected.

GPS Car Computer – Readout Summary

Digital Clock

Shows the current time in 12-hour (AM/PM) format. The seconds are shown in the bottom right. The time is derived from the GPS signal and is accurate to within 100ms (ie, any error is undetectable to a human observer).

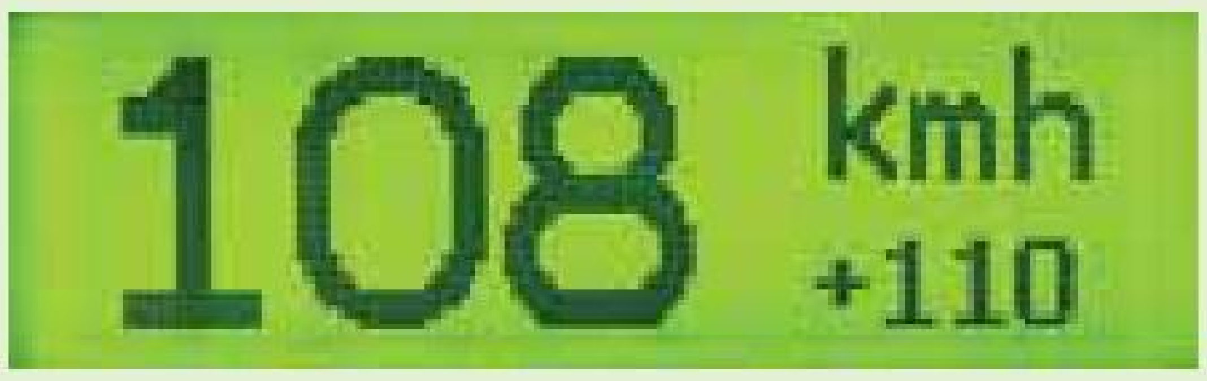
Pressing the Set button will allow adjustment of the time in steps of half an hour (ie, this sets the time zone – the exact time is always derived from the GPS satellites).



Digital Speedometer with Over-Speed Alarm

The digital speedometer will display your speed up to 250km/h. The current setting of the over-speed alarm is shown in the bottom right. An audible alarm (two beeps) will sound when this speed is exceeded and the speedo display will switch to reverse video. Built in hysteresis prevents it from continuously beeping if you stay near this speed.

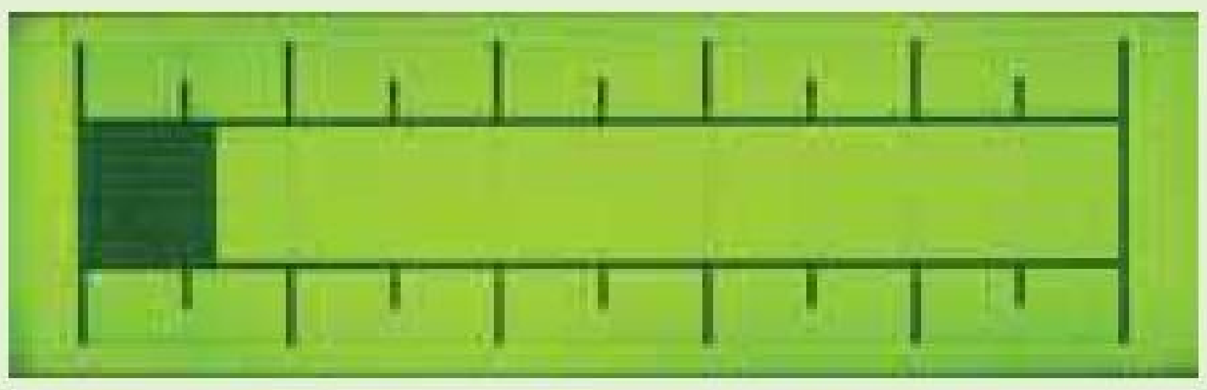
The Set button will change the threshold or completely turn it off when set to zero.



Fuel Economy Meter

The length of the black bar shows the relative fuel consumption for the distance travelled (equivalent to litres per 100km). The longer the bar, the higher the fuel consumption, so you would normally adjust your driving to keep the bar as short as possible.

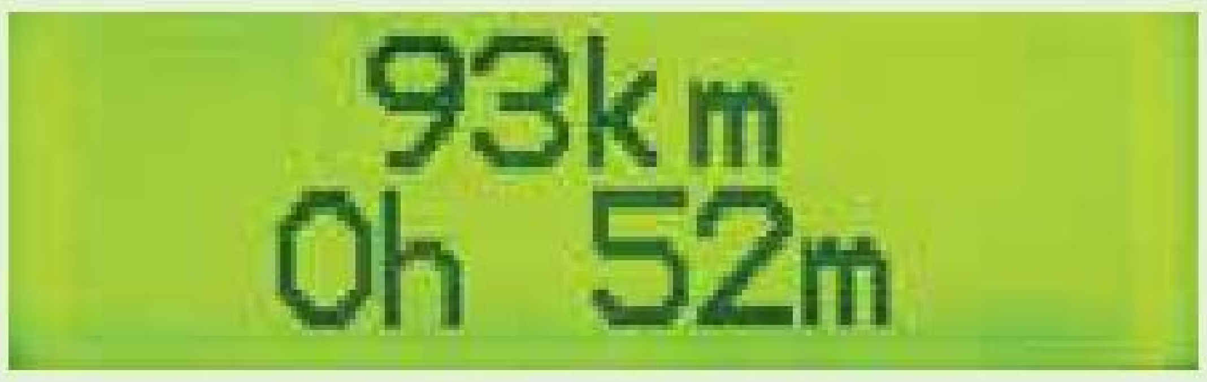
The graph is not calibrated, but the sensitivity (ie, full scale) can be adjusted by pressing the Set button. This allows you to adjust it to suit different vehicles.



Distance and Time to a Destination

This display will count down the distance and time (in hours and minutes) to a destination. The time is based on your average speed over the last ten minutes, so if you get onto a slow road the time to your destination will increase accordingly. This display is reasonably accurate; the error is about one kilometre in 100.

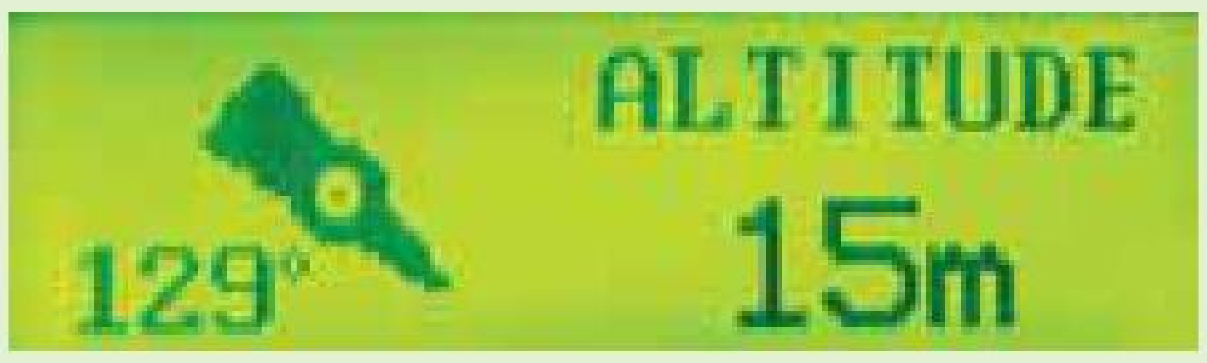
Press the Set button to setup the initial distance to the destination.



Heading, Compass and Altitude

The number on the left is the current heading (direction of the vehicle) in degrees. The needle can show either the heading or point to the north – this is configured by pressing the Set button. The numeric reading will always show the heading.

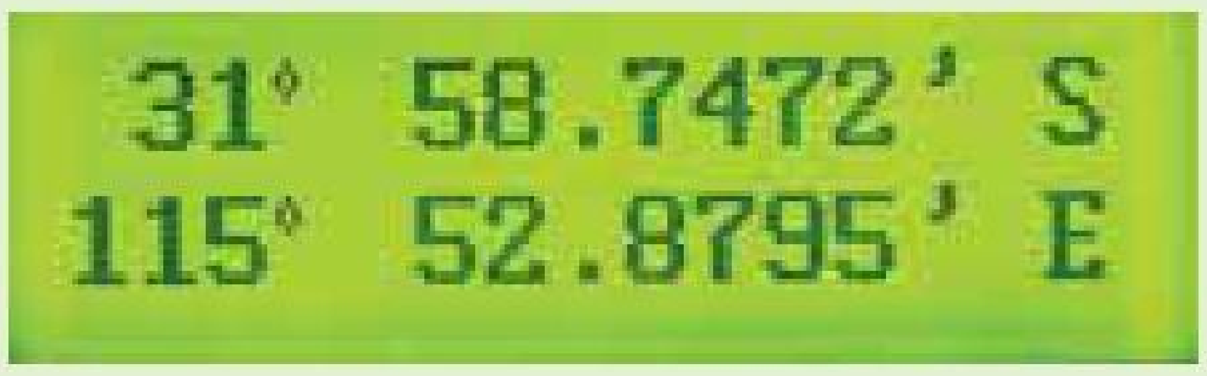
Your current altitude in metres is shown on the right of the screen.



Latitude and Longitude

Your current latitude and longitude is shown as degrees, minutes and fraction of a minute and updates continuously as you drive.

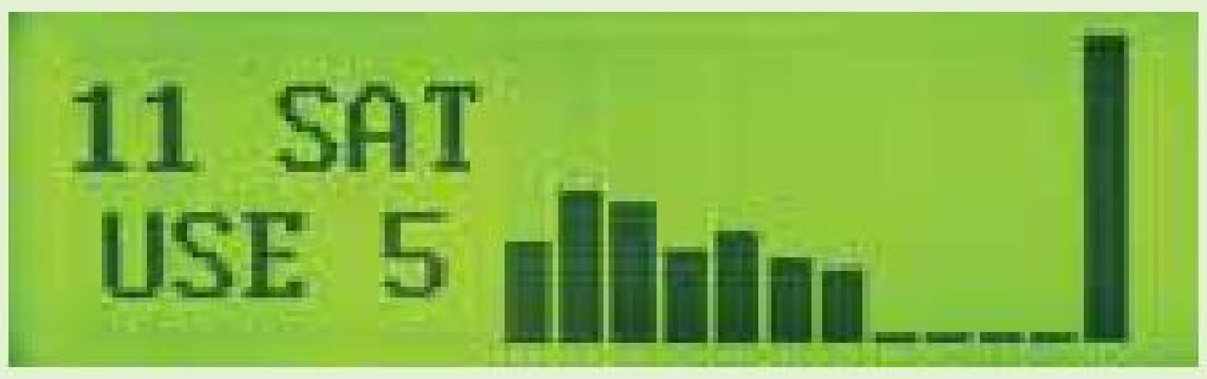
This is accurate to within a few metres depending on the number of satellites that can be found in the sky. This information (and much more) can be sent to your laptop via USB for use by navigation and mapping software.



Current Signal Levels

Shows how many satellites should be in the sky and the number that is currently being used by the GPS module. The bargraph shows the signal level of every satellite that can be detected. The module will not use a satellite if its signal level is below a threshold.

By pressing the Set button you can adjust the backlight brightness for day and night conditions. Day/Night is determined by a light sensor or your car's headlights.



All data is updated once a second. The currently displayed screen and all settings are saved in non-volatile memory and recalled on power up.

the wires and solder to the pads marked CON5. The grey wire goes to pad 1, which is marked accordingly (the left-hand pad when viewing the board from the top). The other wires should be soldered in the same sequence as they emerge from the connector.

As a final check, closely inspect the board with a high power magnifying glass. Carefully check every solder joint for blobs, shorts or poor joints.

Parts List – GPS Car Computer

1 PC board, only available as part of Altronics kit – see text, (140mm × 57mm)
1 EM-408 GPS module manufactured by GlobalSat Technology (available from www.altronics.com.au)
1 SG12232A 122 × 32 dot matrix LCD (Altronics Z7052), or similar
1 20MHz low profile crystal (X1)
1 piezo buzzer – sealed mini PC board type, high output
1 * light dependent resistor, 10kΩ – 1MΩ
3 tactile switches, with 22mm actuating shaft
3 button caps 7.5mm diameter
1 6 pin mini DIN socket, PC board mounting
1 6 pin mini DIN plug
1 B-type USB socket, PC board mounting
1 2-pin header
1 20-pin header
1 20-way header socket, single row (8mm high socket base)
1 U-style micro heatsink for TO-220 (19mm × 19 ×mm 9.5mm)
1 UB3-size plastic box (130mm × 67mm × 43 mm)
4 15mm metal M3 tapped spacer
4 9mm metal M3 untapped spacer
4 20mm M3 bolt
5 10mm M3 bolt
9 M3 Star washer
4 M3 flat washer
5 M3 nut

Semiconductors
1 PIC18F4550-I/P programmed microcontroller (IC1)
1 LM2940CT-5 or LM2938ET-5.0 TO-220 5V voltage regulator (REG1)
1 LP2950CZ-3.3 TO-92 3.3V voltage regulator (REG2)
1 BC338 transistor (Q1)
1 1N4004 diode (D1)
1 1N5819 Schottky diode (D2)

Capacitors
1 100µF 16V electrolytic (105°C rating)
1 10µF 16V tantalum
1 470nF MKT
2 220nF MKT
3 100nF monolithic
2 22pF ceramic

Resistors (0.25W 5%)
1 100kΩ 2 82kΩ* 2 47kΩ* 1 22kΩ 1 10kΩ
1 8.2kΩ* 1 6.8kΩ 2 3.3kΩ 1 10Ω
1 10kΩ trimpot, vertical mount front adjust

New software available on *EPE* website

* = Optional – see text

You can now plug the LCD and GPS into the PC board. When you apply 12V power, your GPS Car Computer should immediately start by showing the firmware version followed by a message indicating that it is searching for satellites.

You will probably have to adjust the 10kΩ trimpot to get an image on the display, and then continue adjusting it for a good contrast. Consult the troubleshooting section if you run into problems.

Installation

The combined PC board and LCD is 123mm wide, 44mm high and about 25mm deep when viewed from the front. This means that it can be mounted in a standard car-radio-sized cutout in the dashboard. Many vehicles have this and are intended for holding small items. The PC board and LCD will even fit in the smaller radio slot found in new vehicles. When mounted in this way, and with a suitable front panel, the GPS Car Computer appears to be part of the vehicle's instrumentation.

In this type of installation, you will probably have to either extend the leads to the GPS module, so that it can be moved to a more sensitive position in the vehicle, or purchase and attach an external antenna. The antenna connector on the GPS module is an MMCX type, and you should easily find a suitable antenna on the Internet (just google for 'GPS antenna MMCX'). Getting a good signal level is very much dependent on the design of the vehicle and the position of the GPS Car Computer, so experimentation will be the order of the day.

We decided to mount our prototype in a standard UB3-size plastic box, so that it could be portable. The stacked PC board and LCD are mounted on the lid of the box, which becomes the back panel, as shown in Fig.11. When the complete assembly is slid into the box, the LCD bezel and the shafts of the pushbuttons will protrude through the base of the box (which becomes the front) as also shown in this diagram, the result is a neat appearance without visible screws.

The LCD bezel should protrude through the front panel so that its front face is flush with the box's outer surface. This means that there will be no need for a window or front glass for the LCD, and the front panel label will cover any roughness in the cutout. To get this flush appearance, you should use the spacers, washers and nuts, as illustrated in Fig.11. If your result is not flush (due to tolerances in the hardware) you may need to add or remove some washers.

To prepare the box you should drill and cut holes as illustrated in Fig.12. These diagrams are reproduced at **80%**, so if you photocopy them at **125%** they can be used as direct templates for positioning the holes and cutout.

To finish the assembly you should copy the front panel design in Fig.13 on to heavy-duty adhesive-backed paper, and then either hot laminate it or cover the printed surface with adhesive-backed clear plastic of the type used to cover books. Then razor cut this paper/plastic sandwich around the edges.

When you cut out the centre of the label for the LCD you will notice that it is a little smaller than the LCD bezel. This is deliberate; as shown in Fig.11, the label is designed to overlap the LCD display bezel by a few millimetres. This hides any roughness in the cutout in the front panel and gives a clean, professional finish. Finally, peel off the backing paper from the label and attach to the front panel.

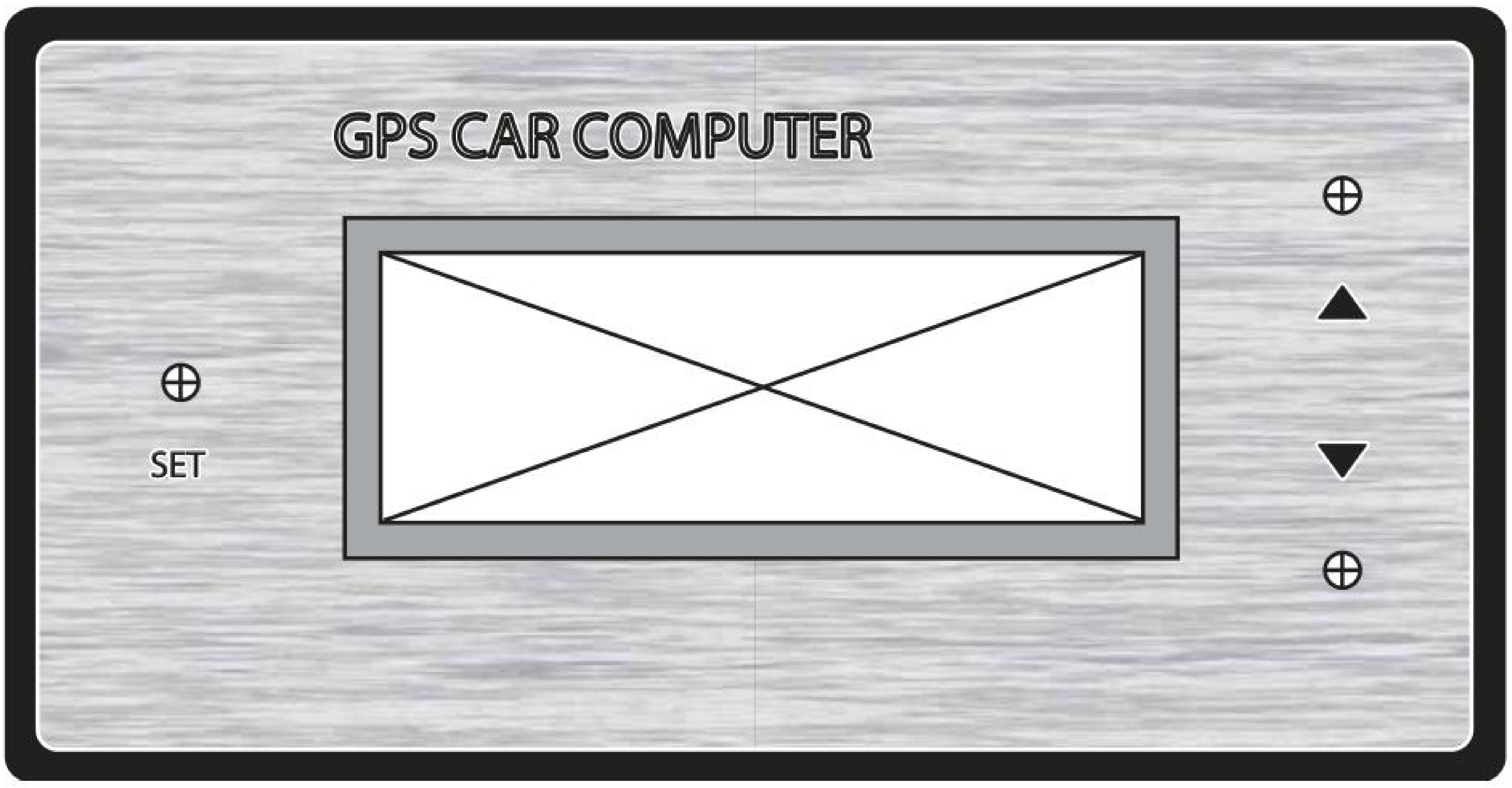


Fig.13: front panel artwork for the GPS Car Computer, reproduced same size, ready for photocopying as described in the text.

GPS module

The GPS module sits horizontally on top of the PC board and LCD boards with its antenna (the brown/silver assembly on the top) pointing to the sky. This is its most sensitive orientation.

To make space for the module you need to use a sharp knife to remove the centre two plastic ribs on the top inside of the box. The module should then sit with its external antenna connector (the gold coloured connector) poking through the hole in the back panel and held in place by the surrounding box and PC board/LCD. If the module rattles around inside the enclosure you will have to attach padding of some type to keep it still.

Troubleshooting

With only a few active components in this project, it should be easy to track down any faults. First, check the two supply voltages as described earlier, as nothing much will happen if they are not correct.

Next, check the microcontroller (IC1). This is best done by measuring the voltage on pin 4, which should be between 1.2V and 1.5V. This voltage is created by the internal voltage reference and implies that the firmware is running, has enabled the reference and configured it for the correct voltage. In other words, it means that the microcontroller is perfectly OK and running its program.

In the absence of this voltage, use an oscilloscope to check for a 20MHz sinewave at pin 13 and pin 14, indicating that the main clock is present. Also check the soldering around the microcontroller for bridges or non-soldered joints.

If the microcontroller is working, the next thing to check is that the pushbuttons are OK. Use a multimeter to check that the switches are open when not pressed and near zero ohms when pressed.

If a button is stuck down it will cause the unit to go into one of several special modes when power is applied, and that may trick you into thinking that the whole unit is not working.

If the actuating arm of a switch is pushed too far to the side this can also cause the switch to close. This can happen if your drilling of the front panel is not accurate.

Next is the LCD. First check the voltage on pin 3 of the LCD (Vcon), it should be under 0.5V. This voltage is controlled by the 10kΩ trimpot (contrast) and if not correctly adjusted the display will appear blank.

The microcontroller only sends data to the LCD and does not expect any response. So, even with the LCD removed or faulty, you should still see signals on the data lines to the LCD. If the LCD is blank or showing rubbish, the only things that you can do is check that it is plugged in correctly and that there are no solder bridges on the connector.

With the microcontroller running and the LCD showing the startup message, the only other fault would be with the GPS module. The microcontroller will display an error message if the module is not connected or running, so that type of fault should be obvious.

The GPS Car Computer could also sit for a long time with the LCD showing a message indicating that it is searching for satellites. This indicates that the GPS module cannot get a signal and moving the unit outside or near a window should correct that. While it is searching, you can press the Set button to get the Signal Levels display – this will show you how many satellites can be seen and their signal levels.

Assuming all is well, we're ready to move into some of the more esoteric aspects of operating the GPS Car Computer, but alas, space has beaten us so that will have to wait until next month.

However, as we said earlier, it really is very simple and quite intuitive to operate, so before the next issue, you'll have a good opportunity to play with it yourself and find out many of the good things it can do.

We've even given you a head start with the various LCD readout screens shown earlier!

Choosing a microcontroller

Readers might be interested in the background of why we chose a PIC18F4550 microcontroller for this project.

Originally, the design started with the Microchip PIC16F877A. This has been around in various incarnations for at least 10 years (a long time in semiconductor circles) and has long been the chip of choice when large pin counts have been required. However, during development we ran into a problem with its limited RAM.

Searching through the Microchip catalogue we found the PIC18F4550. This is a much more modern chip, which has 2048 bytes of RAM – plenty for our requirements. As a bonus it also had four times the program memory, ran four times faster than the venerable PIC16F877A and, if that was not enough, it included a USB 2.0 interface to boot. It had also been used in previous *EPE* projects, so it was not a total stranger.

The clincher was when we checked the Microchip price list. The PIC18F4550 with all its fancy features was 20% cheaper than the plain old PIC16F877A!

As an American would say… the decision was simply a 'no brainer'.

TechnoTalk

Revolutionary Stuff

Mark Nelson

January's the time for making resolutions, but there's no harm in making these revolutionary as well. So let's stir up the mud a bit and challenge established thinking. Mark picks some hot topics.

IF you're one of the unfortunates living in an area with patchy, or non-existent mobile phone coverage, you'll be pleased to know Chancellor of the Exchequer George Osborne has promised £150 million to provide better mobile coverage in Britain. This investment will improve the coverage and quality of mobile services for the 5 to 10% of consumers and businesses that live and work in areas of the UK where existing mobile coverage is poor or non-existent.

The aim is to extend mobile service coverage from the current 95% of the UK population (not the physical landmass) to 99%, beginning in 2012, even though industry experts consider the sum 'totally inadequate'.

Notspots and hot spots

Areas lacking mobile coverage are called 'notspots', a 'clever' coining derived from the wireless hotspots established in shops, pubs, cafes, hotels and transport hubs when mobile Internet coverage was poor. But how did the name hotspot originate?

According to wireless evangelist (and licensed radio amateur) Henry O'Tani, the name was his invention. 'Since originating the concept of community wireless networks in 1998, I have been promoting it passionately world-wide to many organisations. Instead of promoting the idea at commercial trade shows and through normal publicity channels, I chose amateur radio people to spread the words because these are some of the best practical engineers in the world. I was also the first person to operate a microelectronics-controlled, mobile phone cell in the UK'

Since that time commercial and not-for-profit hotspots (**www.wlan.org.uk/operational_wlan_sites.html**) have grown up all around the world.

Nasty tingle

Henry does not confine his talents to hotspots, but as a practical electronicist investigates other fields where conventional wisdom may be letting consumers down. Recently, he discovered a serious electrical incompatibility problem after being approached by someone who was fed up with getting nasty tingles (and small sparks) from the antenna socket and AV/VGA connections to his brand new widescreen television. Worse, this guy found it impossible to integrate the set with his audio setup because of earth loop noise.

Henry knows of several items of audio equipment that have had their input circuits damaged when connecting to modern (switchmode) powered equipment. This includes mobiles, smartphones, laptops, cameras and external hard drives and CD players.

No mystery

Although the reason for this unpleasant state of affairs seems to have been overlooked by the IET, and other UK electrical equipment standards authorities, the source of the problem is no mystery to Henry.

Nowadays, most electrical equipment is manufactured in the Far East, principally for the North American market. Not surprisingly, it is wired for the USA type of power socket configuration, in which both line connections are live, but 180° out of phase.

This is in contrast to Britain, where the neutral (N) line is nominally at earth (ground) potential. Consequently, using switchmode power supplies designed for the North American market will cause problems when connected to our kind of mains wiring.

Says Henry, 'If you examine circuit diagrams of modern switchmode power supplies you generally find not one, but two small high voltage HF noise and transient spike suppression capacitors connected across the line inputs, with the common connection taken to the floating appliance or equipment's chassis. When connected to an American 3-pin socket these provide a virtual earth for HF and RF noise and fast transient spikes.

Unfortunately, the neutral connection at nominal earth potential of UK wiring will turn these low-value capacitors into a very undesirable AC voltage connection (of typically 125kΩ impedance at 50Hz) between line and chassis (and signal connector shells) of the otherwise floating device.'

If you check with a regular (10MΩ) high-impedance voltmeter or 'scope you will find approx half the AC mains RMS voltage on a 'two wire' SMPS-equipped TV, laptop or camera chassis. The situation is that the connected device's chassis (signal common in normal unbalanced connections) is fed 165V peak via a 125kΩ 'AC resistance'.

If the earth return is, say, 40mΩ (approx 2m of mm^2 cable), the 'potential divider' formed of 125kΩ and 1/50th of an ohm puts a significant 26µV of 50Hz AC on a connected unbalanced feed, which is well within the –60dB audible threshold for sensitive (microphone and amplifier-type) low-level input signal levels.

Most desktop PC chassis have IEC connectors, so they are grounded, but are not compatible with 'clean' low-level signals. Moreover, if the 'grounding connection' of the 3-pin connector is broken momentarily (as when hot plugging), the high voltage is applied momentarily to the 'signal common' line. Even at 125kΩ impedance, 162V peak is enough to damage FET and IC input circuits.

Ironically, such equipment will often pass the UK's mandatory personal appliance testing (PAT) safety testing regimes, although (for this reason?) 'computer equipment' was subsequently exempted from the high voltage insulation test!

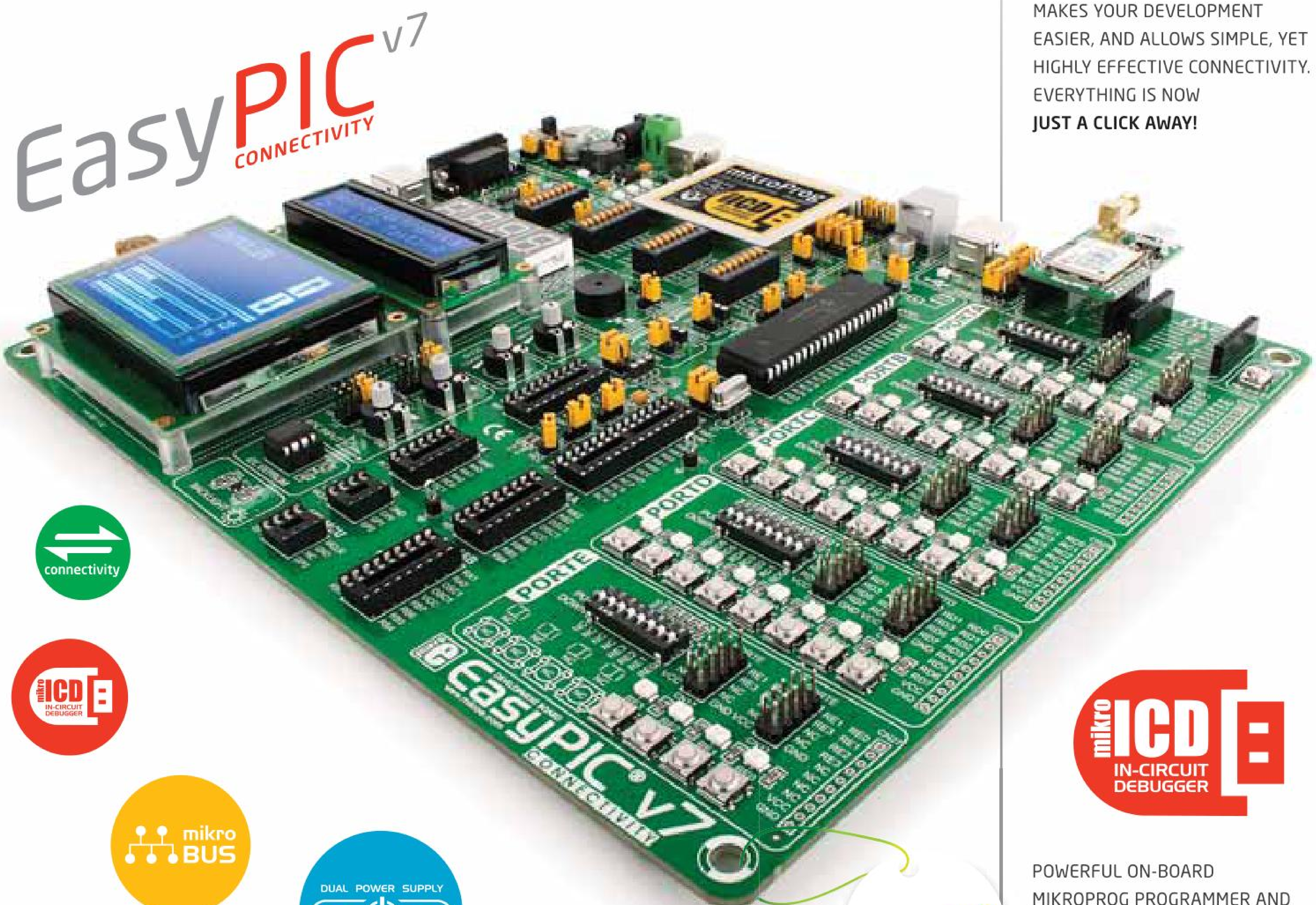
What do readers think? Is Henry right to be concerned? Should we insist on action, or at least on warning labels?

How green are you?

Finally here's a wake-up call to everyone who uses the Internet. Are you aware of the extent to which the Internet grosses out on global energy consumption?

'If the Internet was a country, it would be the planet's fifth-biggest consumer of power, ahead of India and Germany. The Internet's power needs now rival those of the aviation industry and are expected to nearly double by 2020,' states Canadian academic and green IT expert Mohamed Cheriet. 'The Internet is very, very power-hungry, and we have to reduce its carbon footprint.'

If the energy consumed came from green power sources it would not be so bad, but the technologies of the 21st century are still largely powered by the dirty coal-power of the past, according to a Greenpeace report titled *How Dirty is Your Power?* This is because some of the world's largest data centre clusters (Google, Facebook and Apple) are based in places where cheap and dirty coal-powered electricity is abundant. Time to take action?



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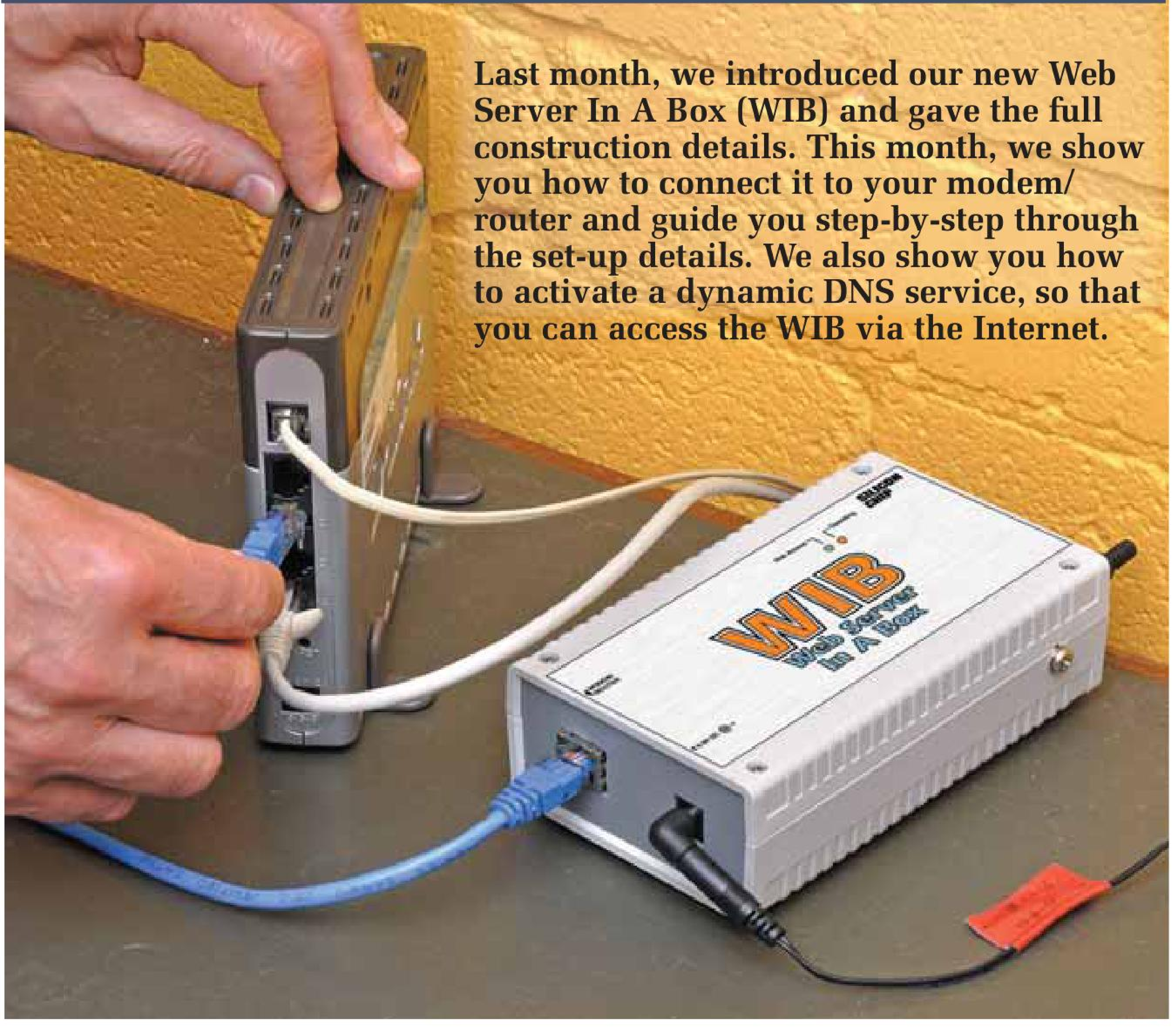
WIB

Part 2: By MAURO GRASSI

Web Server In a Box



Last month, we introduced our new Web Server In A Box (WIB) and gave the full construction details. This month, we show you how to connect it to your modem/router and guide you step-by-step through the set-up details. We also show you how to activate a dynamic DNS service, so that you can access the WIB via the Internet.

IN ORDER to access the WIB over the Internet, you must have an account with an ISP (eg, BT, Virgin, Sky). You must also have a router connected to the modem or you can use a combined modem/router. In fact, this is the most common set-up where you have more than one device sharing your Internet connection.

In summary, the set-up procedure involves the following eight steps:

Step 1: Physically connect the WIB to your network (this involves connecting it via an Ethernet cable to your router or modem/router).

Step 2: Change the DHCP range of your modem/router (ie, the range of IP addresses it can automatically assign to other devices on the network) to prevent conflicts with the static IP assigned to the WIB.

Step 3: Enable port forwarding (or virtual server) in your modem/router for the HTTP and FTP servers.

Step 4: Directly copy the provided website and configuration files onto the WIB's memory card using a PC.

Step 5: Modify the **settings.txt** file so that you can connect to the WIB via the local network using your web browser.

Step 6: Configure each module in turn by changing the settings via the browser. These modules are:
a) The HTTP (web) server
b) The SNTP client (for network time)
c) The FTP server (to allow files to be uploaded or downloaded)
d) The SMTP email client (for email notifications)
e) Dynamic DNS (domain name server) to allow access via the Internet.

Step 7: Set up the analogue variables, so that you can monitor the analogue sensors (eg, temperature).

Step 8: Create new default values once the set-up is finished.

Step 1: Connect the WIB to your modem/router

THERE ARE several ways of connecting this device to your local network.

First, if you have a combined modem/router with a spare Ethernet port, then it's simply a matter of connecting the WIB to it using a straight-through ethernet cable, as shown in Fig.9(a). Alternatively, if the router is separate, then the WIB should be plugged into this, along with the modem, as shown in Fig.9(b).

If you don't have a spare Ethernet port on your modem/router, then the connection will have to be made via a network hub. This situation will typically arise if you only have one port on a combined modem/router,

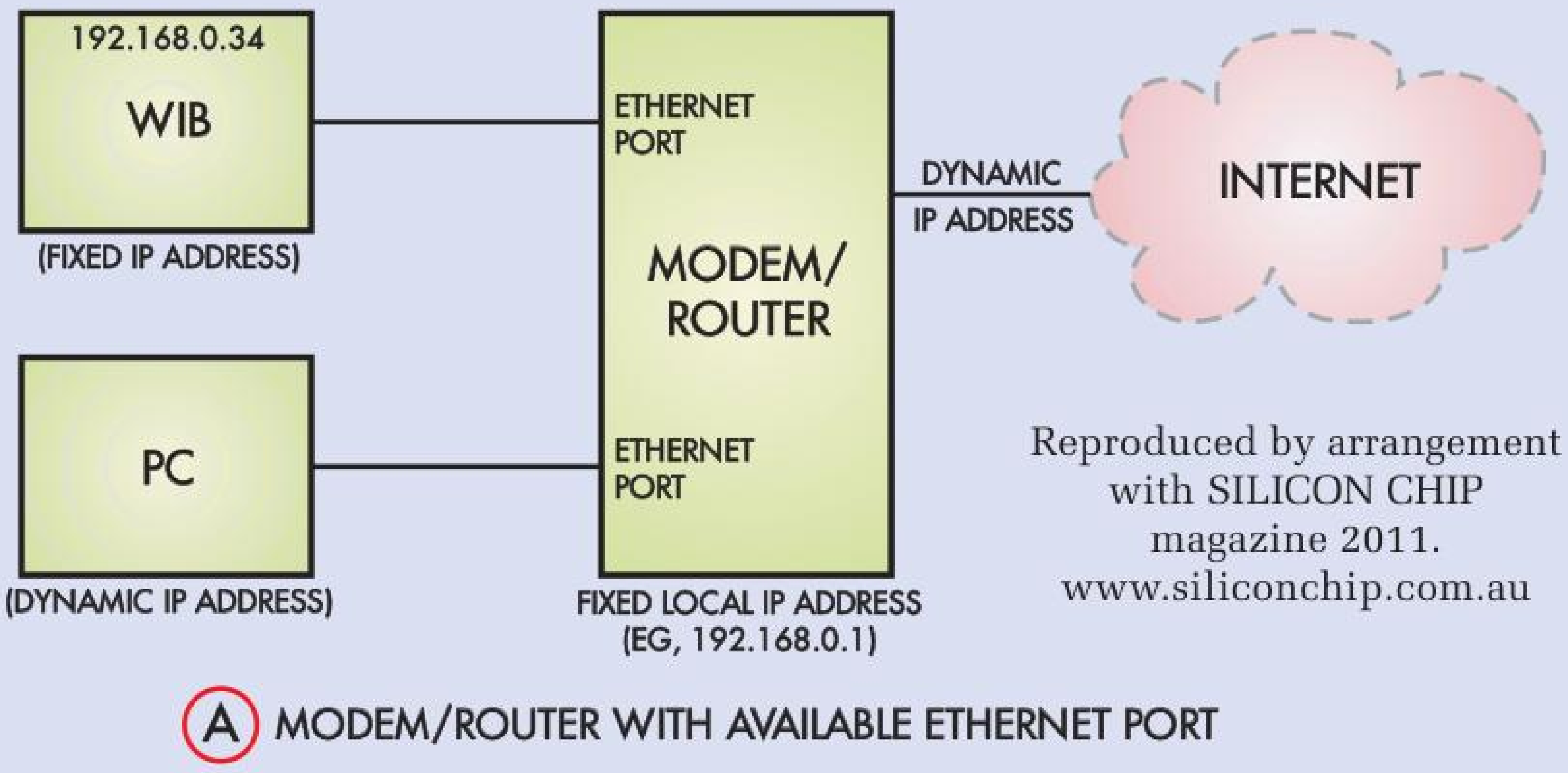


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Fig.9(a): here's how to connect the WIB to your local network if you have a combined modem/router (be sure to use straight-through Ethernet cable). If your modem/router uses a 10.x.x.x fixed IP address, then you will have to change the IP address of the WIB accordingly (eg, if the modem/router uses 10.0.0.1, then change the WIB's address to 10.0.0.34).

Step 1 CONTINUED . . .

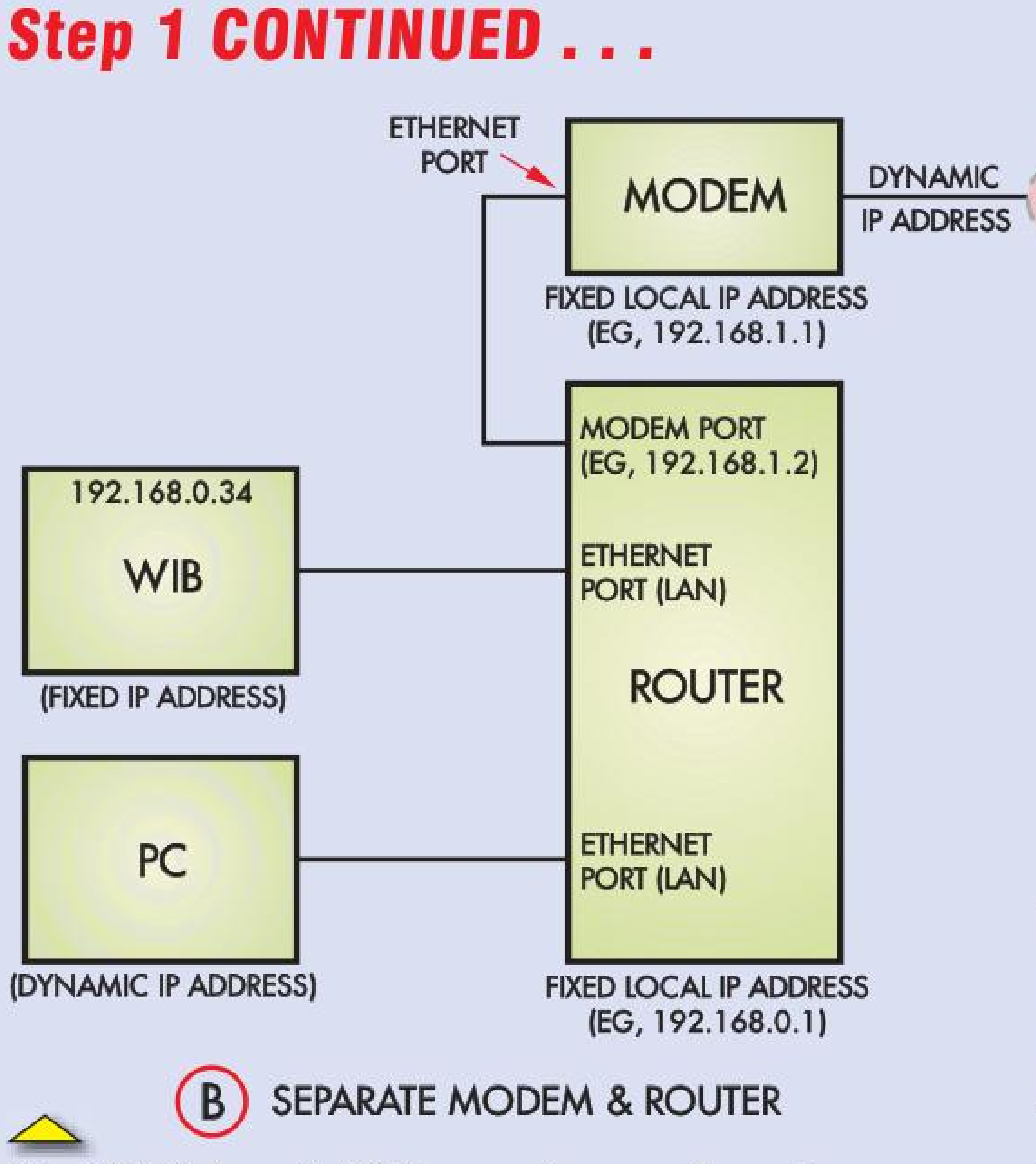
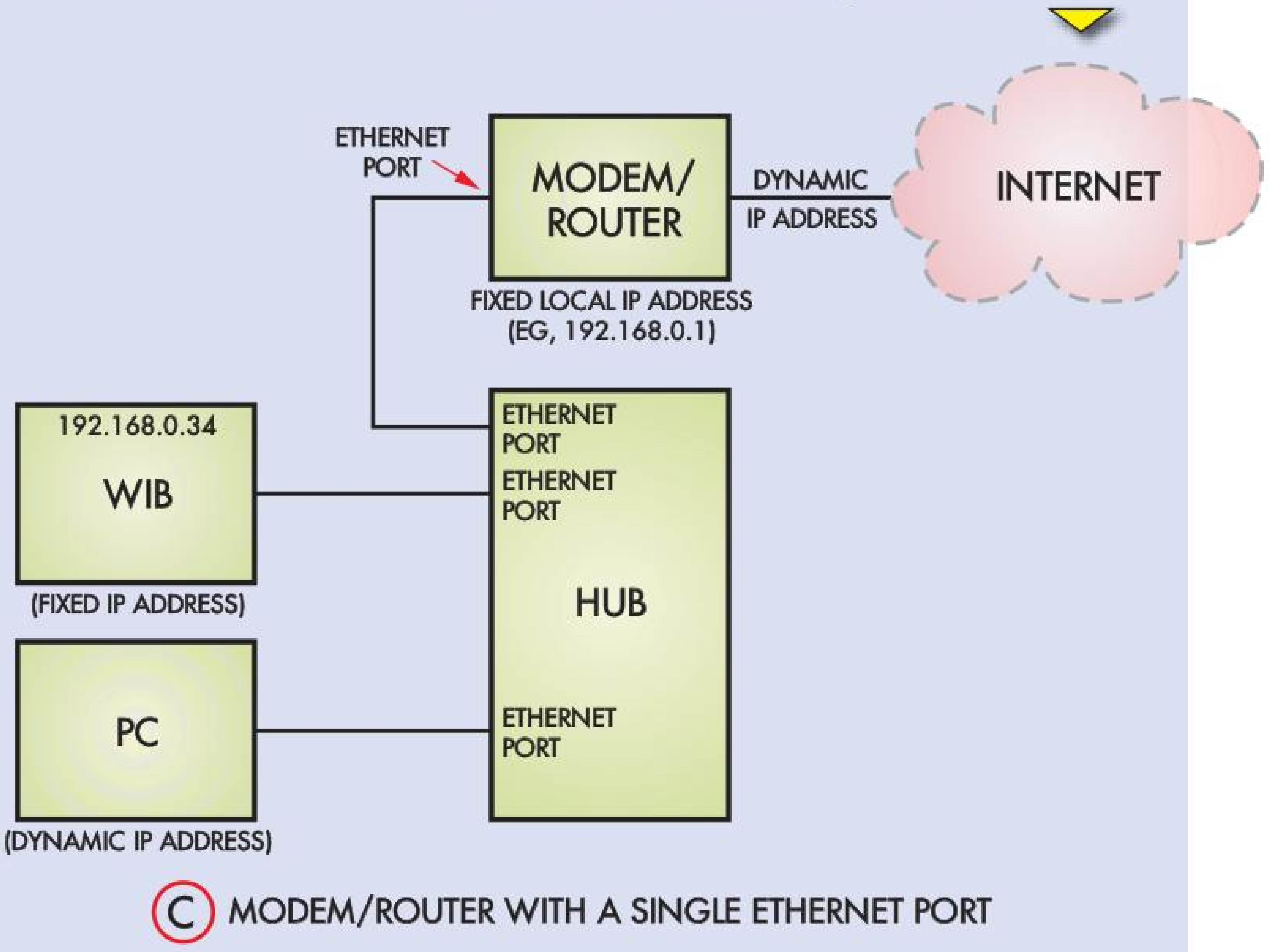

ETHERNET PORT
MODEM
DYNAMIC IP ADDRESS
INTERNET
FIXED LOCAL IP ADDRESS (EG, 192.168.1.1)
MODEM PORT (EG, 192.168.1.2)
192.168.0.34
WIB
(FIXED IP ADDRESS)
ETHERNET PORT (LAN)
ROUTER
PC
ETHERNET PORT (LAN)
(DYNAMIC IP ADDRESS)
FIXED LOCAL IP ADDRESS (EG, 192.168.0.1)
B SEPARATE MODEM & ROUTER

Fig.9(b) (above): if the modem and router are separate, then connect the WIB as shown here. As before, use straight-through Ethernet cable to make the connections and change the WIB's IP to suit the network if the inward facing (local) IP of the router uses a 10.x.x.x address, or some other addressing scheme.

Fig.9(c) (below): this is the scheme to use if your modem/router has only one Ethernet port, but it is normally taken by your PC or some other device. In that case, you need to connect both the PC and the WIB to separate ports on a hub. The modem/router is then connected to another port. The WIB's IP address should normally be outside the DHCP range (see text).


ETHERNET PORT
MODEM/ ROUTER
DYNAMIC IP ADDRESS
INTERNET
FIXED LOCAL IP ADDRESS (EG, 192.168.0.1)
192.168.0.34
WIB
(FIXED IP ADDRESS)
ETHERNET PORT
ETHERNET PORT
HUB
PC
ETHERNET PORT
(DYNAMIC IP ADDRESS)
C MODEM/ROUTER WITH A SINGLE ETHERNET PORT

but that's already used to connect your PC. In that case, the PC will have to be disconnected from the modem/router, and both it and the WIB connected via a hub, as shown in Fig.9(c).

Note that, in all cases, we're assuming that the PC is assigned a dynamic IP address by the DHCP server in the router. Alternatively, it can be configured with a static IP. The default static IP of 192.168.0.34 for the WIB is also shown, but this can be changed to suit the network if necessary, as we shall see later.

Note that all the connections are made using straight-through Ethernet cable (usually blue).

Step 2: Change the modem/router's DHCP range

IN MOST networks, a DHCP server in the modem/router is used to hand out dynamic IP addresses to any devices on that network. By contrast, the WIB uses a fixed IP address. As a result, the DHCP range must be restricted to avoid this address, to prevent conflicts.

Alternatively, you can reserve a fixed (static) IP address for the WIB within the DHCP server range. Again, this prevents it from handing out the WIB's IP address to some other device on the network.

If you leave the WIB's IP at the default 192.168.0.34, the easiest approach in most cases is to restrict the DHCP range so that is covers from 192.168.0.2 to 192.168.0.33. Or, you can specify that DHCP addresses start from 192.168.0.35.

The first step is to log into your router using a web browser. Your router has a fixed IP address on the network (192.168.0.1 is a common default) and this is often (but not necessarily) the address that's also used to access its set-up pages (this can be checked in the router's manual). You will also need the username and the password for the modem/router.

In the case of a D-Link DI-524, for example, the set-up address is the same as the LAN address, and it's just a matter of entering 192.168.0.1 in the browser, followed by the username and password at the log-in prompt. The default username and password differ according to the manufacturer, but in any case, you should have changed these for security reasons when you first set up your modem/router.

Once logged in, you then navigate to the DHCP set-up page and set up the DHCP address range. Make sure that the IP address of the WIB falls outside this range, to avoid any conflicts. You will need to specify a big enough address range to accommodate all the devices on your network that rely on DHCP.

You then save the settings and reboot your modem/router to make the settings stick. An example screen grab using a D-Link DI-524 router is shown in Fig.10, while Fig.11 shows the settings for a Motorola SBG900 cable modem/router. Note that the latter has a fixed network address of 192.168.0.1, but its set-up is accessed using 192.168.100.1.

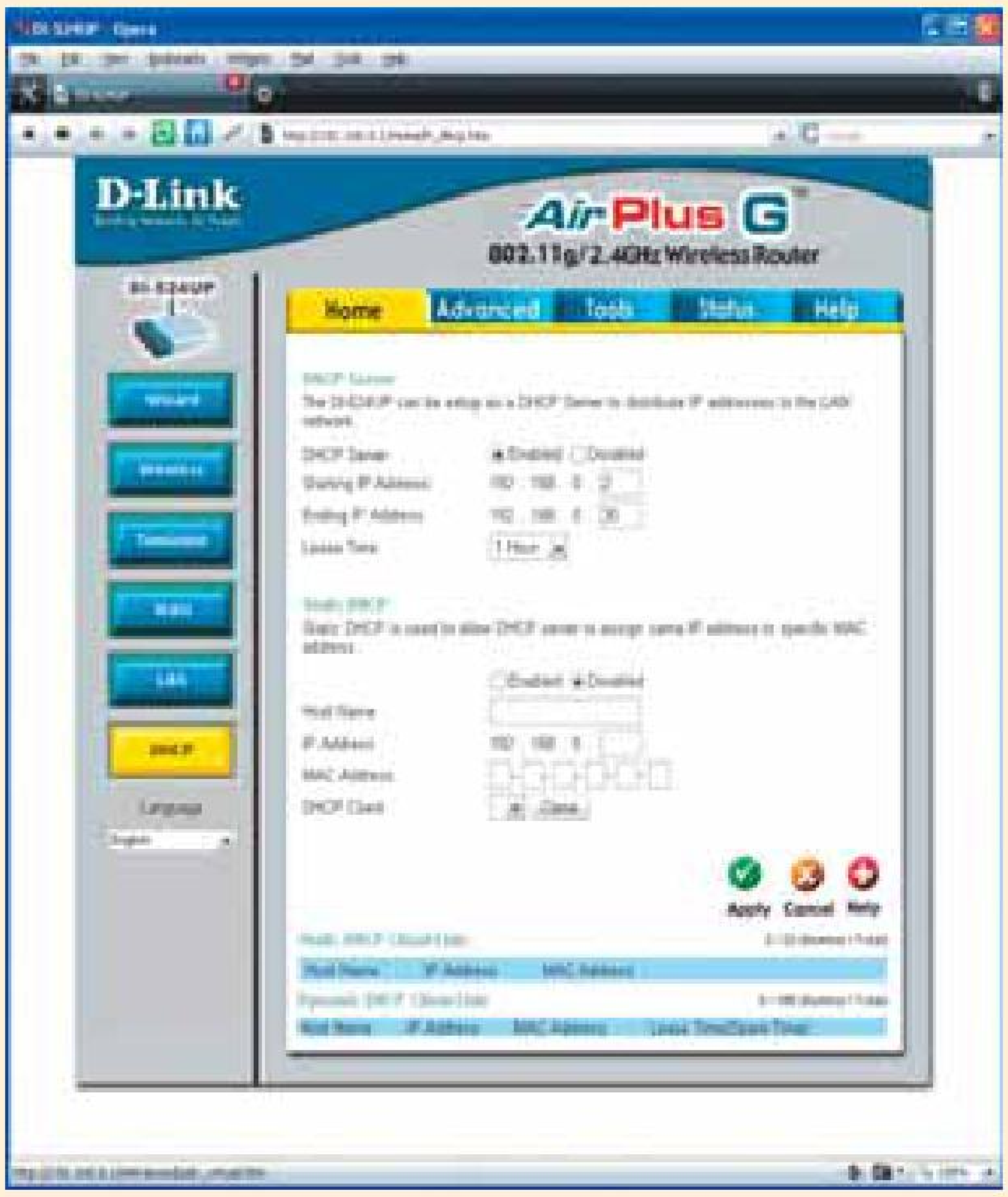


Fig.10: configuring the DHCP server range in the D-Link DI-524 modem/router. Note that, for most modem/routers, the WIB's address should be outside this range.

For the Motorola SBG900, it's a matter of navigating to ***Gateway – LAN – DHCP Server Config*** and entering in the starting IP address and the number of DHCP users (see Fig.11). **Unlike most other modem/routers though, the DHCP range here must include the WIB's IP address, otherwise you will not be able to configure port forwarding later on (see below).** You must then reserve a fixed IP address for the WIB and for any other device with a fixed IP that falls within the DHCP range.

That's done by associating an IP address with the MAC address of each such device – see Fig.12. You can discover the MAC address of each device on a network by entering **ipconfig /all** at a command prompt. The MAC address of the WIB is also indicated on its *Basic Settings* page – just enter **192.168.0.34/basic.cgi** in a web browser and log in (**admin** and **pass** are the default username and password entries respectively).

Don't forget to reboot the modem after making these changes, so that the settings take effect.

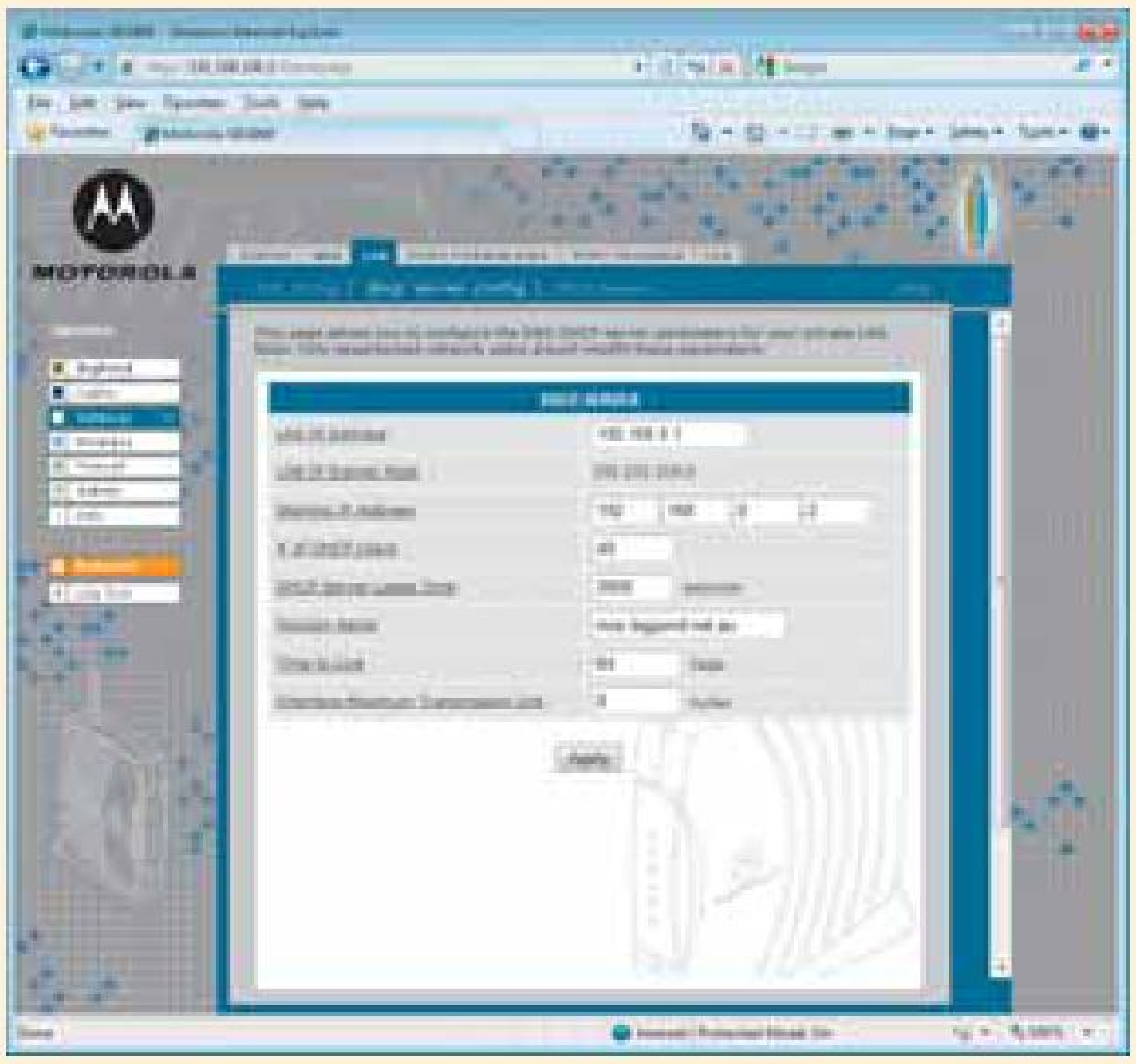


Fig.11: the DHCP server configuration for the Motorola SBG900 cable modem/router. Unlike the set-up for most other units, the DHCP range in this case must include the WIB's IP address to allow port forwarding. The WIB's static IP address is then reserved – see below.

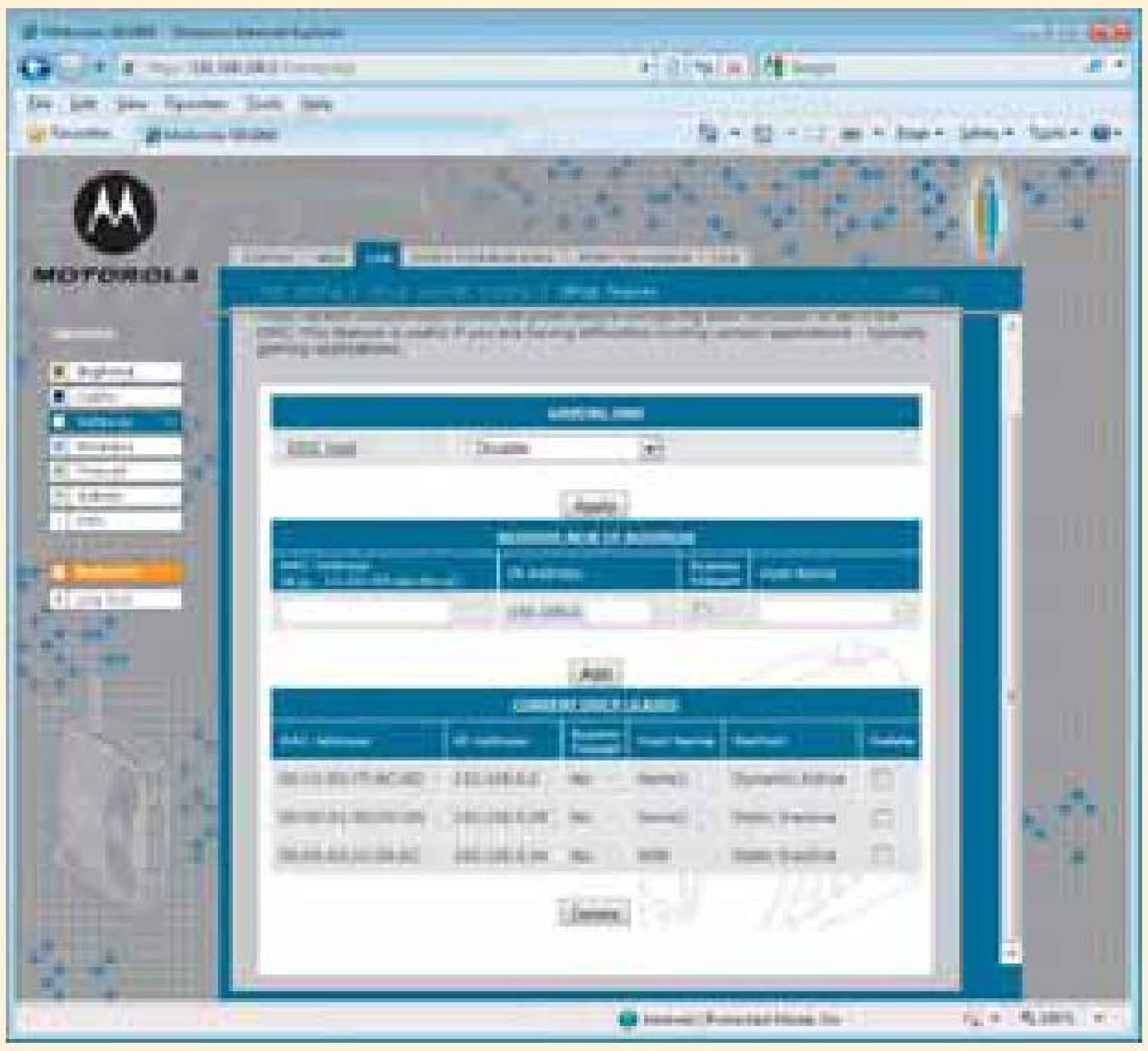


Fig.12: the WIB's static IP address (along with the fixed IP of any other device) is reserved in the SBG900 as shown here. It's done by assigning a fixed IP to the MAC address of each device – see text.

Step 3: Configure port forwarding and the firewall

THE ADDRESS assigned to the modem by your ISP is known as the 'public IP address'. This is the address that's presented to the Internet. At the same time, the modem (or modem/router) also has a private (inward facing) IP address, which it presents to the home network – see Fig.9(a), Fig.9(b) and Fig.9(c).

In operation, the router stores information on the outgoing packets and then uses this information to determine where to route the response on the home network. This is called *Network Address Translation* or NAT.

NAT also acts as a kind of firewall, since any unsolicited requests from outside are dropped by the router. However, in this case, we want HTTP and FTP requests directed at

Step 3 CONTINUED . . .

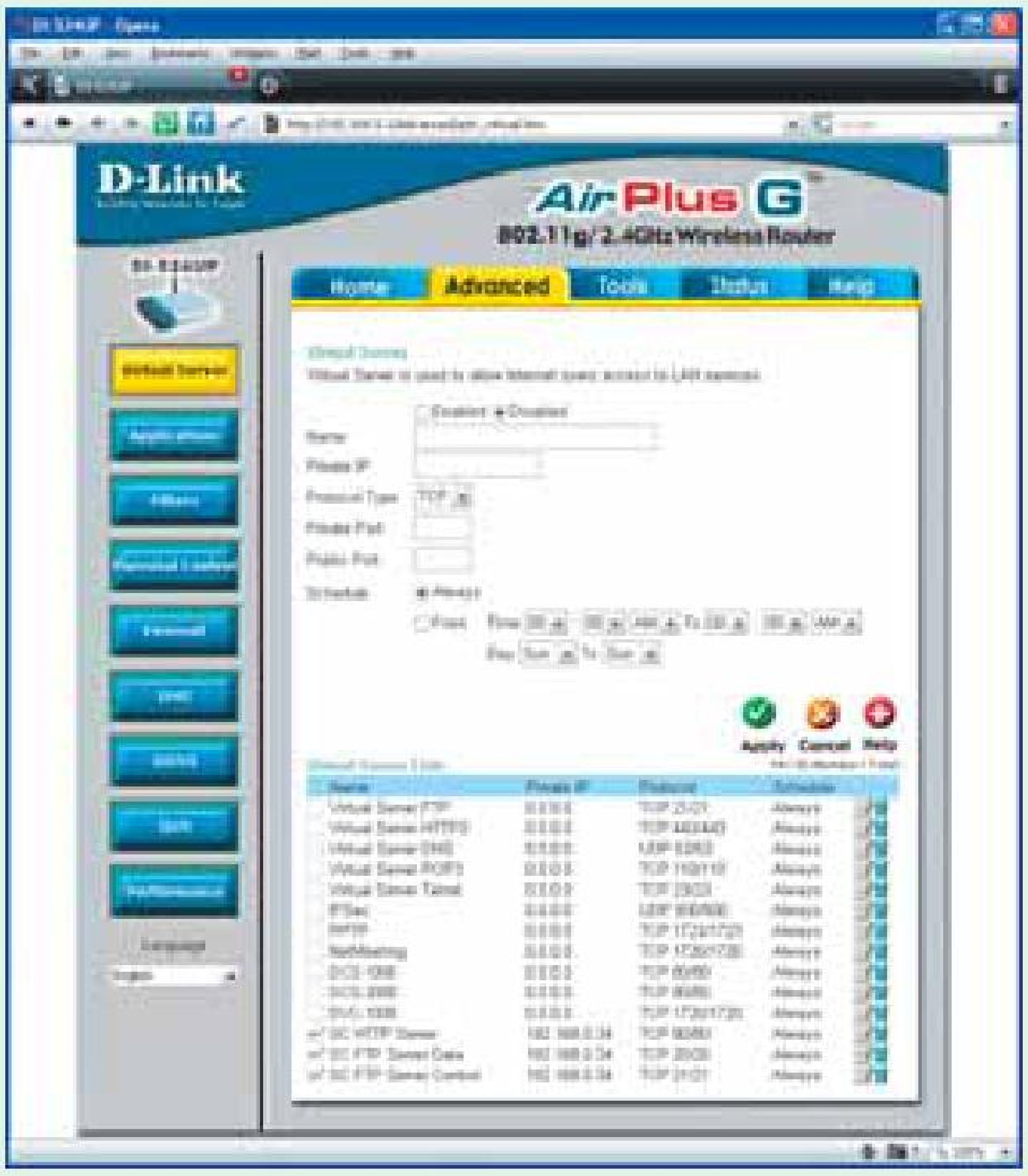


Fig.12: virtual server set-up in the D-Link DI-524. Ports 80, 20 and 21 (all TCP protocol) must be forwarded to the WIB's IP address, and these ports, along with ports 25 (TCP) and 123 (UDP), must also be open in the firewall.

the public IP address (ie, from the Internet) to be forwarded to the WIB's private IP address. This is where 'port forwarding' comes in.

Port forwarding is a way of making your router redirect incoming traffic on a particular port to a private IP address on your home network. In this case, to access the WIB's website from the Internet, we need to redirect incoming traffic on HTTP port 80 to the WIB's static IP address. In addition, you also need to redirect traffic on the common FTP ports (20, 21) to provide FTP access from the Internet.

Port forwarding goes under different names, and some routers may call it 'virtual server' instead. You will need to log into your router using a web browser to change the port forwarding settings. **For web access, you need to enable forward port 80 to 192.168.0.34, while to enable FTP access, you need to forward ports 20 and 21 to the address.**

Example set-ups

Let's take a look at a couple of example set-ups, the first being for a D-Link DI-524 router (the procedure for your modem/router will be similar).

As explained previously, the DI-524's set-up pages are accessed by entering 192.168.0.1 (ie, the same as its private IP address) into a web browser. You then enter the username and password to log in.

Once logged in, it's then just a matter of clicking the Virtual Server button and defining entries to port-forward TCP port 80 (for HTTP) and TCP ports 20 and

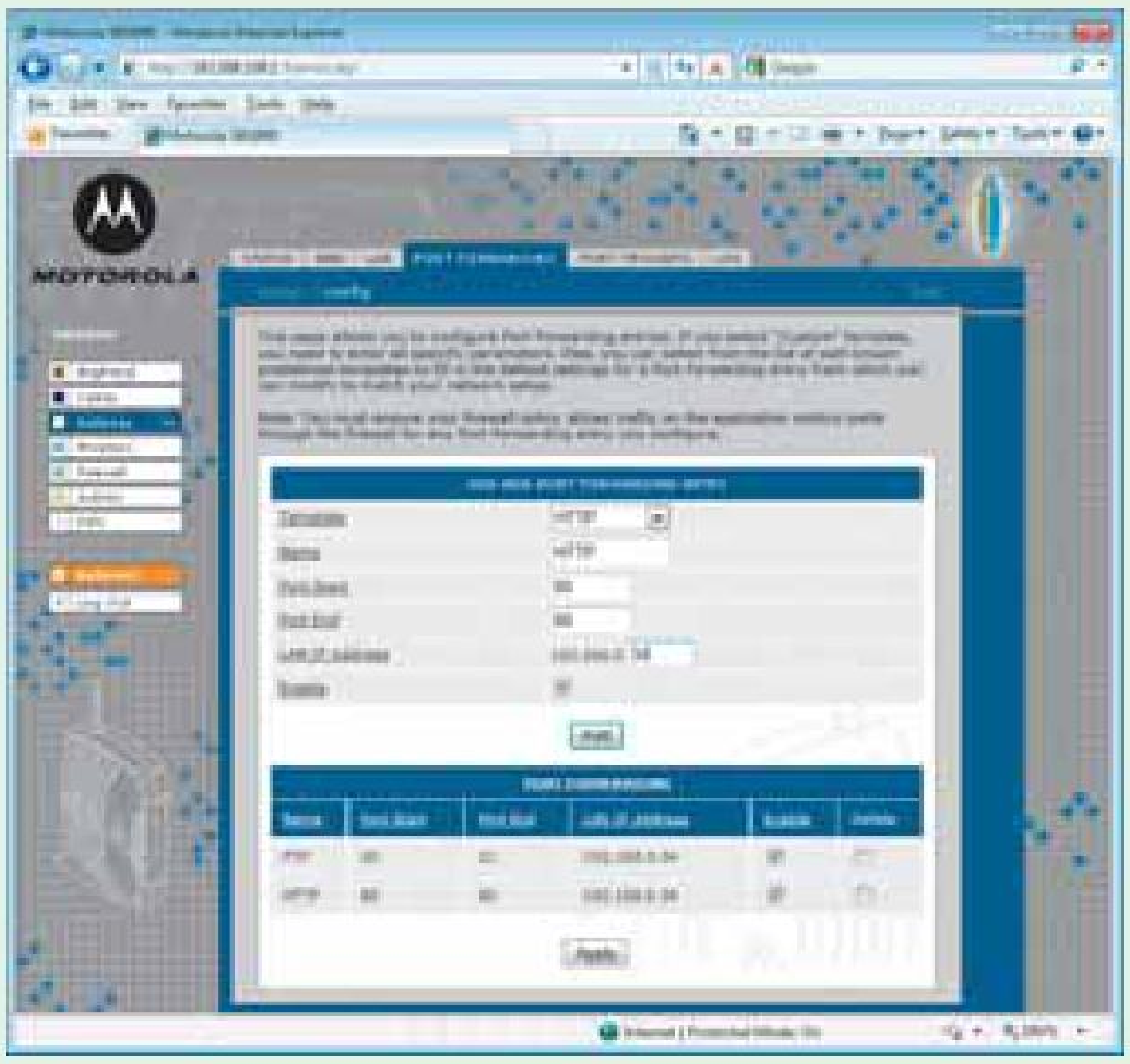


Fig.13: port forwarding set-up on the Motorola SBG900 modem/router. Unlike the D-Link DI-524, it allows you to specify a port range.

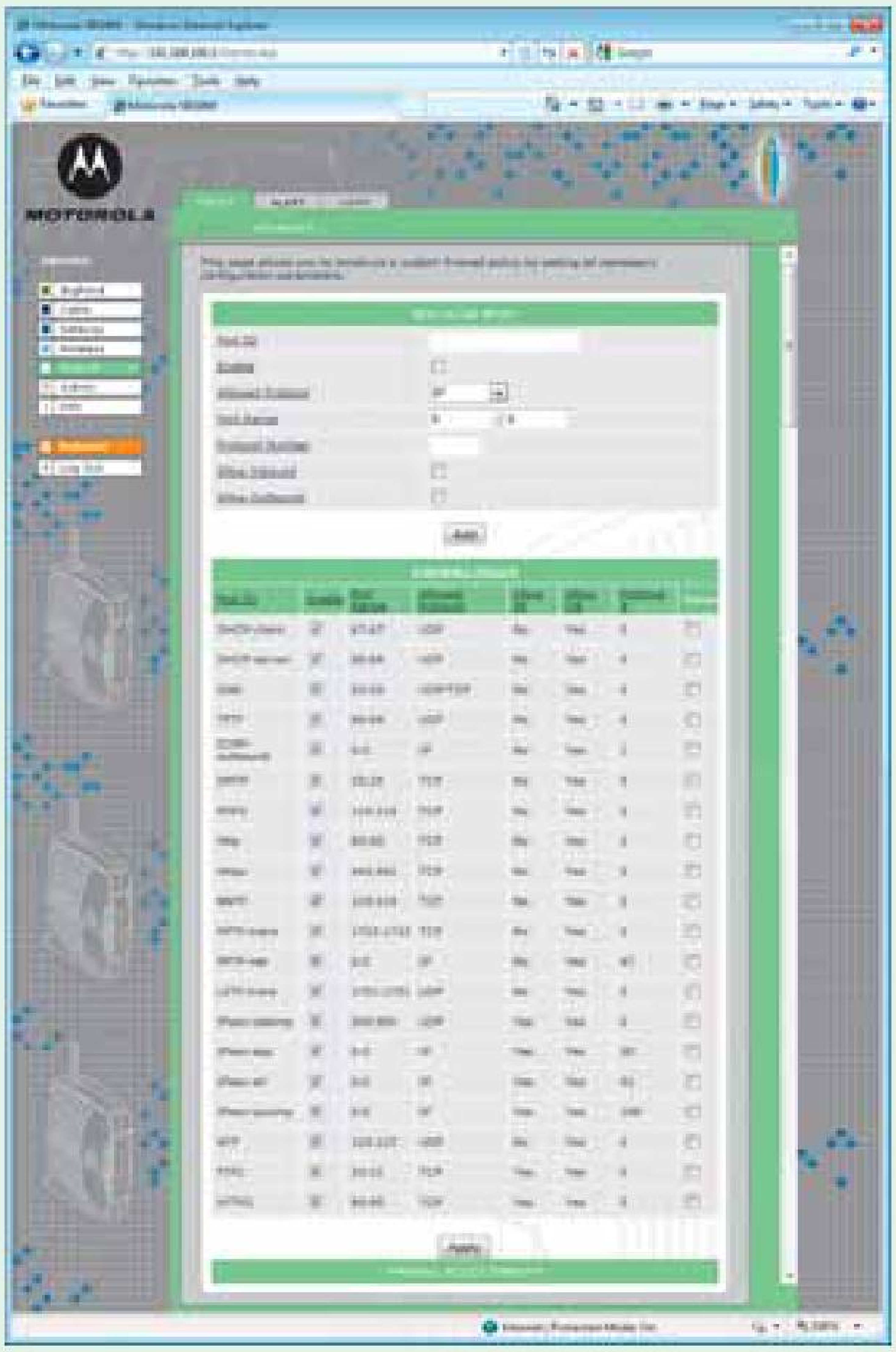


Fig.14: setting up port forwarding automatically adjusts the firewall settings on some modem/routers, but this must be done manually in the SBG900. Ports 20, 21 and 80 (TCP) must be opened in both directions, while ports 25 (TCP) and 123 (UDP) must be opened in the outbound direction only.

21 (for FTP) – see Fig.12. In each case, they should be forwarded to the static IP address of the WIB (eg, 192.168.0.34).

Note that FTP ports 20 and 21 have to be defined separately here. Alternatively, some modem/routers let you define a port range.

Once port forwarding has been enabled for HTTP and FTP, you will probably have to reboot the router for the changes to take effect.

Fig.13 shows the corresponding port forwarding settings for the Motorola SBG900 cable modem. Unlike the D-Link DI-524, this modem lets you define a port range, so we only need a single entry for FTP (ie, port range 20-21).

Note that if you have a separate modem and router, you will have to turn on port forwarding (or change the virtual server settings) for each. It won't work if you only do it for the modem, for example, since the router would then drop any incoming requests.

For example, let's say that you have a modem with an internal IP address of 10.0.0.1 and a router with a matching external address of 10.0.0.3 (ie, on its modem port) and an internal address of 192.168.0.1. In that case, you configure the modem to forward ports 20, 21 and 80 to 192.168.0.1. The router is then configured to forward these ports to the WIB's private IP address (eg, to 192.168.0.34).

Check the firewall

Once you've turned on port forwarding, you also need to make sure that the relevant ports are opened in the firewall. On some modem/routers, this happens automatically when port forwarding is enabled (eg, D-Link DI-524). By contrast, on the Motorola SBG900, you have to open the relevant ports yourself.

The protocol to use for both HTTP and FTP is TCP, and **you have to allow traffic in both directions.** In addition, you have to open port 123 to allow NTP (or SNTP) requests to an Internet time server. In this case, the allowed protocol must be UDP, and you only need to allow outbound requests – see Fig.14.

You will have to do this, regardless of what type of modem/router you have. Check also that port 25 (SMTP) is open for outgoing TCP packets, otherwise the WIB will not be able to send email (this port will already be open if you are successfully using a PC to send email).

As with port forwarding, if you have a separate modem and router, you have to configure the firewall on each. Alternatively, turn one of the firewalls off – you don't need both.

Step 4: Copy files to the memory card

THIS STEP involves copying the provided website files and the default settings file to the memory card. You will need a compatible memory card and a card reader so that you can read and write to the card using a PC.

Many laptops now come equipped with card readers as standard, or you can use an external card reader with a USB interface like those shown last month. You can use any MMC, SD or SDHC memory card to store the files, since all three types are compatible with the WIB.

The memory card must be formatted to the FAT/FAT32 file system. If it uses some other file system, then it will have to be reformatted (just right-click the drive and click 'Format'). Note that you may want to back up whatever was on the card before you do this; remember that formatting will erase everything that's on the card.

Next, download the file **ewswebsite.zip** from the *EPE* website. Unzip this file's contents and then copy all the unzipped files directly to the memory card's root folder. After this is done, your memory card's root folder should look like the screen grab shown in Fig.15.

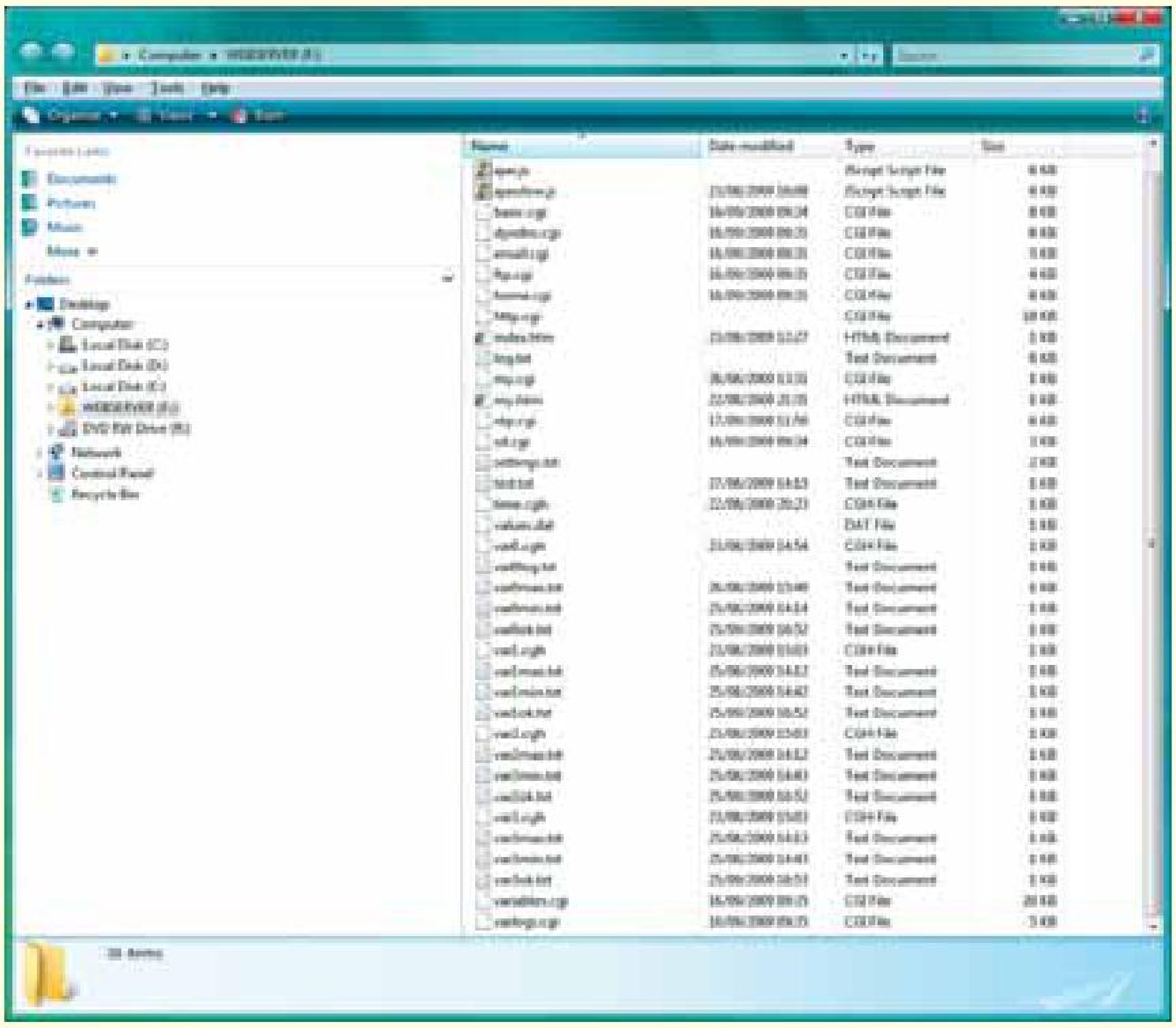


Fig.15: the WIB's website files must be downloaded (in *ewswebsite.zip*) from the *EPE* website and copied to the memory card.

Step 5: Configure minimal settings

HAVING COPIED the files to the memory card, the next step is to open the ***settings.txt*** file in a text editor and enter in a few basic (or minimal) settings. These are the settings that are necessary for you to access the WIB using a web browser (ie, when the card is installed in the WIB).

First, you need to determine the gateway address of your network. This is the LAN (local area network) IP address of your router. Typically, this will be either 192.168.0.1 or 192.168.1.1, but other numbers are also commonly used (eg, 10.0.0.1), depending on the router.

The default IP will be listed in the router's manual and can also be checked by accessing the router's set-up pages. It can also be discovered by entering the command **ipconfig /all** in a command prompt window on your PC.

The resulting dialog will show not only the gateway address, but also the IP addresses of other devices on the network, the subnet mask, the device MAC addresses and the addresses of your ISP's DNS servers.

As a minimum, the WIB must be provided with the following information to get it working on your home network:

- **IP Address:** this is the address of the WIB, and should be an unused address on your home network. As stated previously, the default value is 192.168.0.34, but change this to suit your network if necessary (eg, if you are using 10.x.x.x network IP addresses).

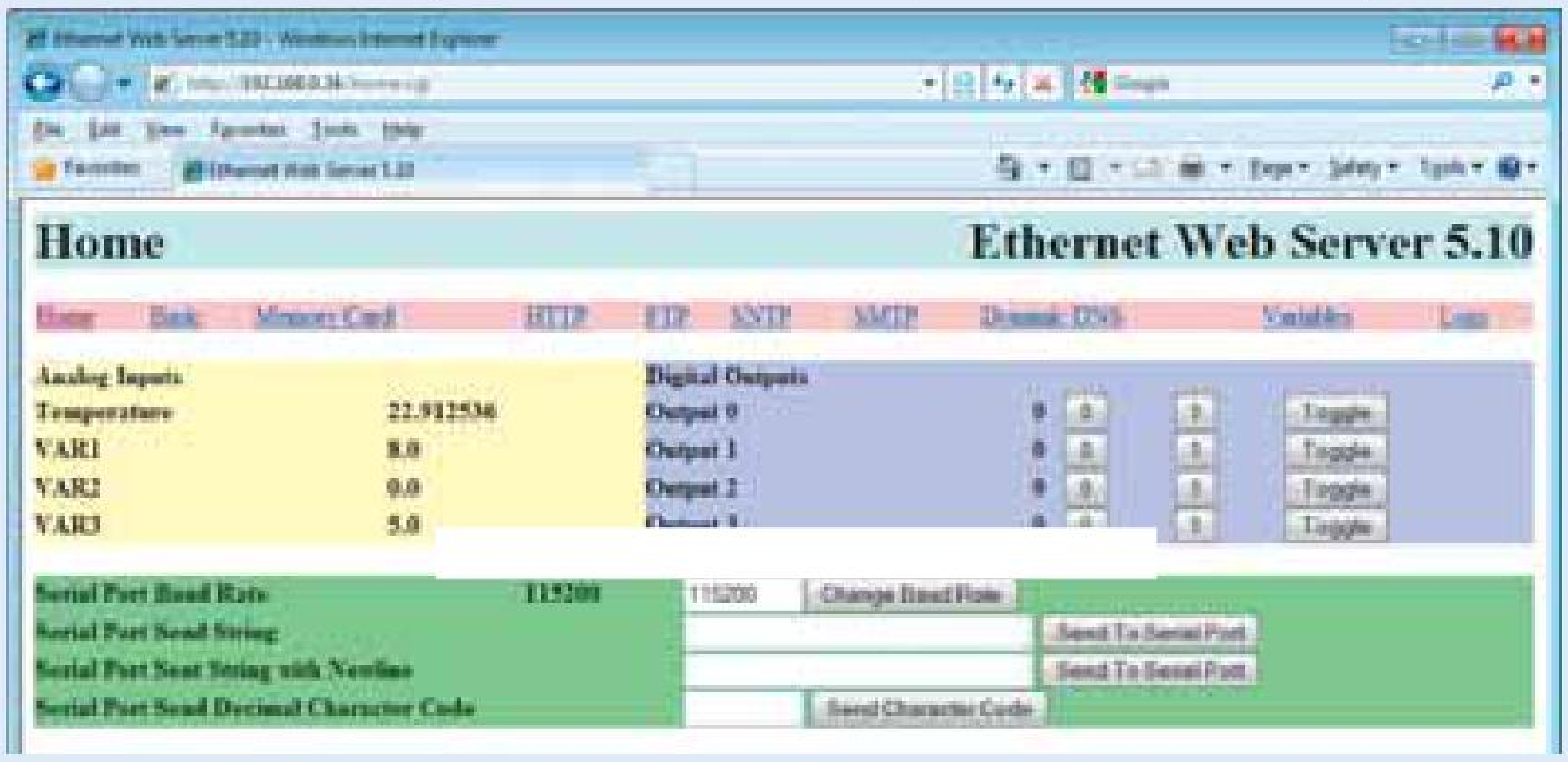
If your network uses DHCP to hand out IP addresses, then you must follow the procedure described in Step 2 to restrict the DHCP range or to reserve a static (or fixed) IP address for the WIB, to avoid conflicts. Alternatively, you can reserve a range of fixed addresses and any address in this range can be then be used for the WIB.

- **Gateway Address:** this is the IP address that the WIB uses to communicate with the Internet. This is simply the LAN IP address of your router (typically 192.168.0.1) and can be checked as described above.
- **Subnet Mask:** this is the mask that determines your home network's subnet. This will typically be set to 255.255.255.0 (the default) but some networks might require 255.255.0.0.
- **Primary DNS Server:** this can usually simply be set to the IP address of the router (ie, the same as the Gateway Address). In some cases though, it may be necessary to enter in the address of your ISP's primary DNS server, as some routers don't function as DNS relays. **In particular, if the WIB fails to pick up network time later on, try entering your ISP's primary DNS server address here.**

Once again, use the command **ipconfig /all** to discover the DNS addresses if necessary.

- **Username:** this is the username that's used to log into the WIB's HTTP server (and also to log into the FTP server). The default is 'admin'.
- **Password:** this is the password that's used to log in to the WIB. The default is 'pass'.

The settings are each entered on a separate line and it should look like this (default values shown):

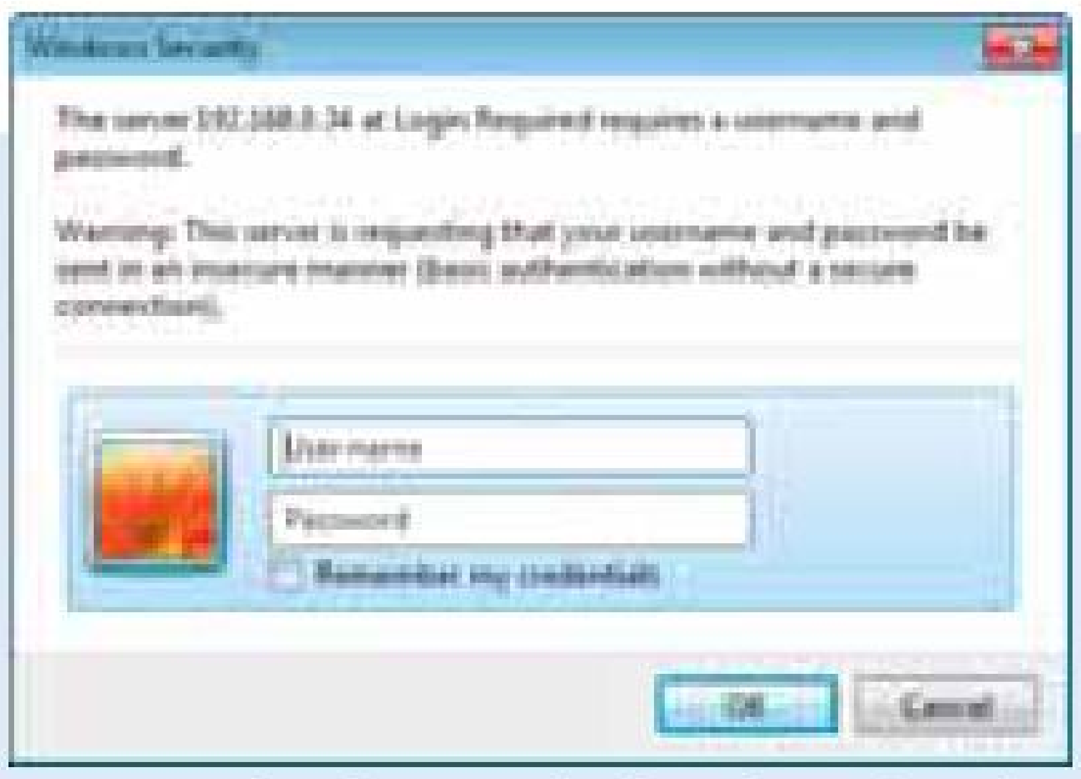

Ethernet Web Server 5.10 - Windows Internet Explorer
File Edit View Favorites Tools Help
Favorites
Ethernet Web Server 5.10
Home
Ethernet Web Server 5.10
Home Back Memory Card HTTP FTP SNTP SMTP Dynamic DNS Variables Logs
Toggle
Change Baud Rate
Send To Serial Port
Send Character Code

Analog Inputs
Temperature 22.912536
VAR1 8.0
VAR2 0.0
VAR3 5.0

Digital Outputs
Output 0 0 0 1
Output 1 0 0 1
Output 2 0 0 1

Serial Port Baud Rate 115200 115200
Serial Port Send String
Serial Port Sent String with Newline
Serial Port Send Decimal Character Code

Fig.17: the WIB's home page displays the analogue input values and lets you toggle the digital outputs on or off. You can also send data to the serial port.



The server 192.168.0.34 at Login Required requires a username and password.

Warning: This server is requesting that your username and password be sent in an insecure manner (basic authentication without a secure connection).

Fig.16: the log-in dialog box for the WIB's website. Be sure to change the default username and password.

```
IP Address = 192.168.0.34
Gateway = 192.168.0.1
Subnet Mask= 255.255.255.0
Primary DNS = 192.168.0.1
User = admin
Password = pass
```

In memory

Replace the values as appropriate using a text editor on your PC and save the changes to the memory card. **As a minimum, you should replace the default 'user' and 'password' values. The security of the WIB depends on the username and password not being easy to guess, otherwise you could**

Missed connection

In the December 2011 issue of *EPE* we published Part 1 of the *Web In A Box* project. Unfortunately, about a week after this issue was printed it transpired that the relevant SD Card Socket is no longer available. The reason for this is the manufacturer will only supply orders in quantities of 10,000 or more, which is just not feasible for the hobbyist kit market. We are trying to source an alternative socket with the same pinouts, so far without success.

Due to this problem, in our March issue (on sale in February 2012) details of a suitable workaround will be published along with a brief explanation of how to 'hook-up' an alternative SD-Media socket to the board without using a special PCB. This information will also be available on our website (**www.epemag.com**).

While the *EPE* editorial team do research the projects that are published, I am afraid to say that these things do occur occasionally. Late-breaking news and updates are available in the *Shop Talk* section of our forum, at **www.chatzones.co.uk**.

As we go to press, Jaycar is selling a complete kit, including the correct SD Card Socket. However, before purchase we would recommend you check with Jaycar that they are indeed including the correct socket. Kit number KC5489 from **www.jaycar.com.au**. – *The Editor*

get an unwanted guest logging in and inspecting your email set-up details.

Once you've modified the above parameters in the **settings.txt** file, eject the memory card from the reader and insert it into the WIB (it can only go in one way). The remaining entries in the **settings.txt** file are left as they are, since further changes are now made by accessing the WIB using your web browser. The resulting changes are then saved in a separate binary file called **values.dat**.

With the memory card now in place (and the unit connected to your router), apply power and check the orange and green front panel LEDs. These should both light for a few seconds and then the green LED should go out, while the orange LED should flash at a 0.5s rate (ie, twice a second), indicating that the unit has 'booted'. The green LED inside the RJ45 connector should be lit (indicating a valid Ethernet link) and you should also occasionally see the yellow LED in the RJ45 connector light (ie, when data is being transferred).

If it all checks out so far, launch your web browser (Internet Explorer, Opera, Firefox, Safari, Chrome), type 192.168.0.34/home.cgi in the address bar and press Enter (*note: be sure to use the correct IP address for the WIB if you've changed it from the default IP*). A login window should now appear – see Fig.16.

Next, enter your username and password and click OK. The WIB's home page should now appear (Fig.17). This shows the values of the four analogue inputs and the state of the four digital outputs. The latter are all off (logic 0) by default, but you can toggle them by clicking the Toggle buttons.

You now use the WIB's website to change all the other settings, and we're going to do that right now.

Step 6: Configure the modules

THIS STEP involves configuring each module of the TCP/IP stack in turn, beginning with the Basic Settings.

Before we start though, note that each time you change an entry here, you must click its associated 'Change' button to store the value in the values.dat file. The WIB must also then be restarted for any changes to take effect (ie, by clicking the 'Master Reset' button.

- **Basic Settings:** begin by clicking on the Basic link to bring up the page shown in Fig.18. This should show all the settings you entered at Step 5, so there should be little (if anything) to do here. However, you may wish to set a secondary DNS server (to act as a backup if the primary DNS server is temporarily out).

To do this, simply enter its IP address and click the 'Change Secondary DNS' button. Don't forget to reboot the WIB for the setting to take effect.

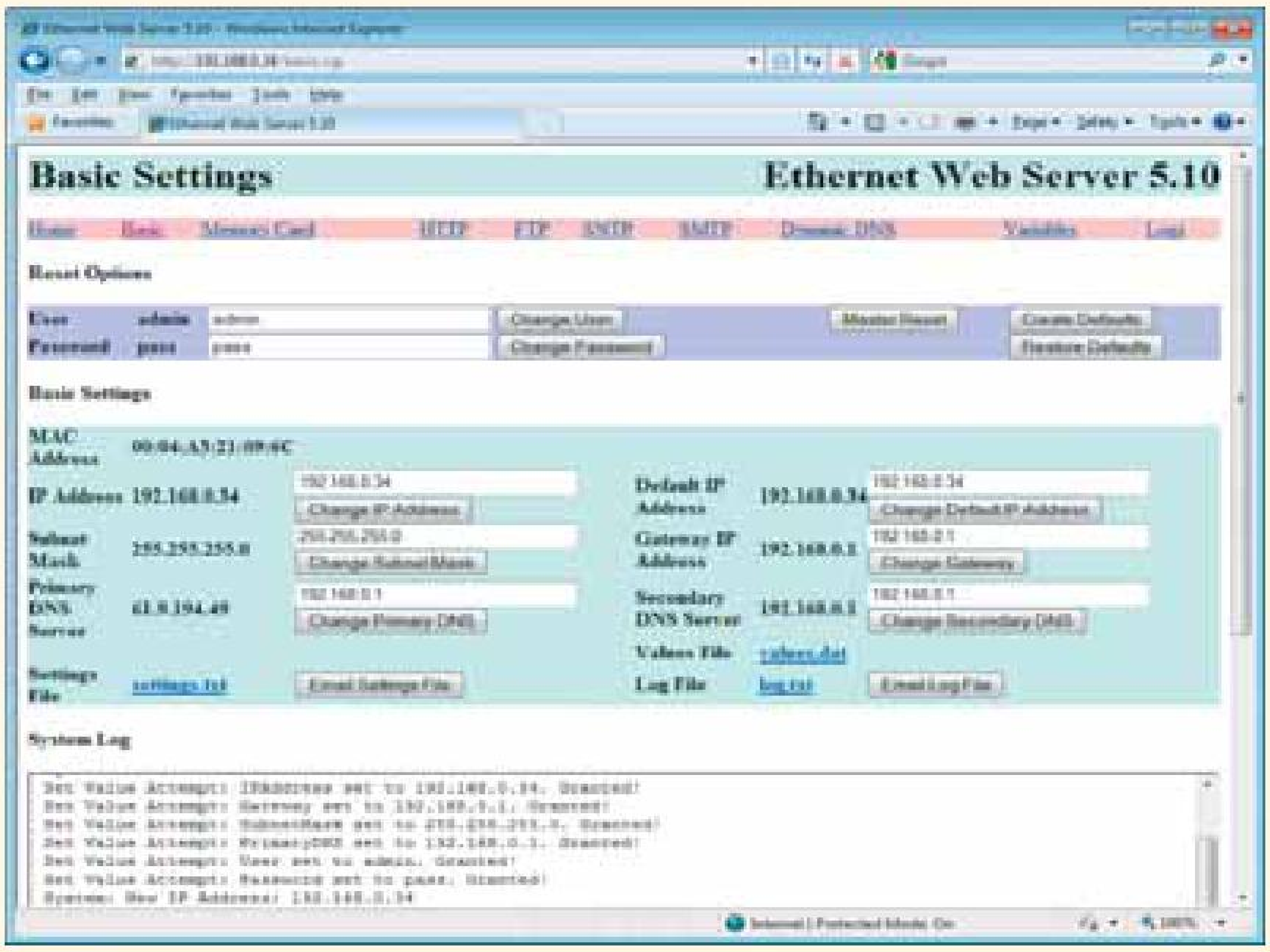


Fig.18: the Basic Settings page should show all the settings you entered into the *settings.txt* file in Step 5, but you can make further changes here.

- **HTTP Settings:** Fig.19 shows the HTTP Settings page. However, before going further, we should emphasise that the default values will be suitable for most users and can be left just as they are.

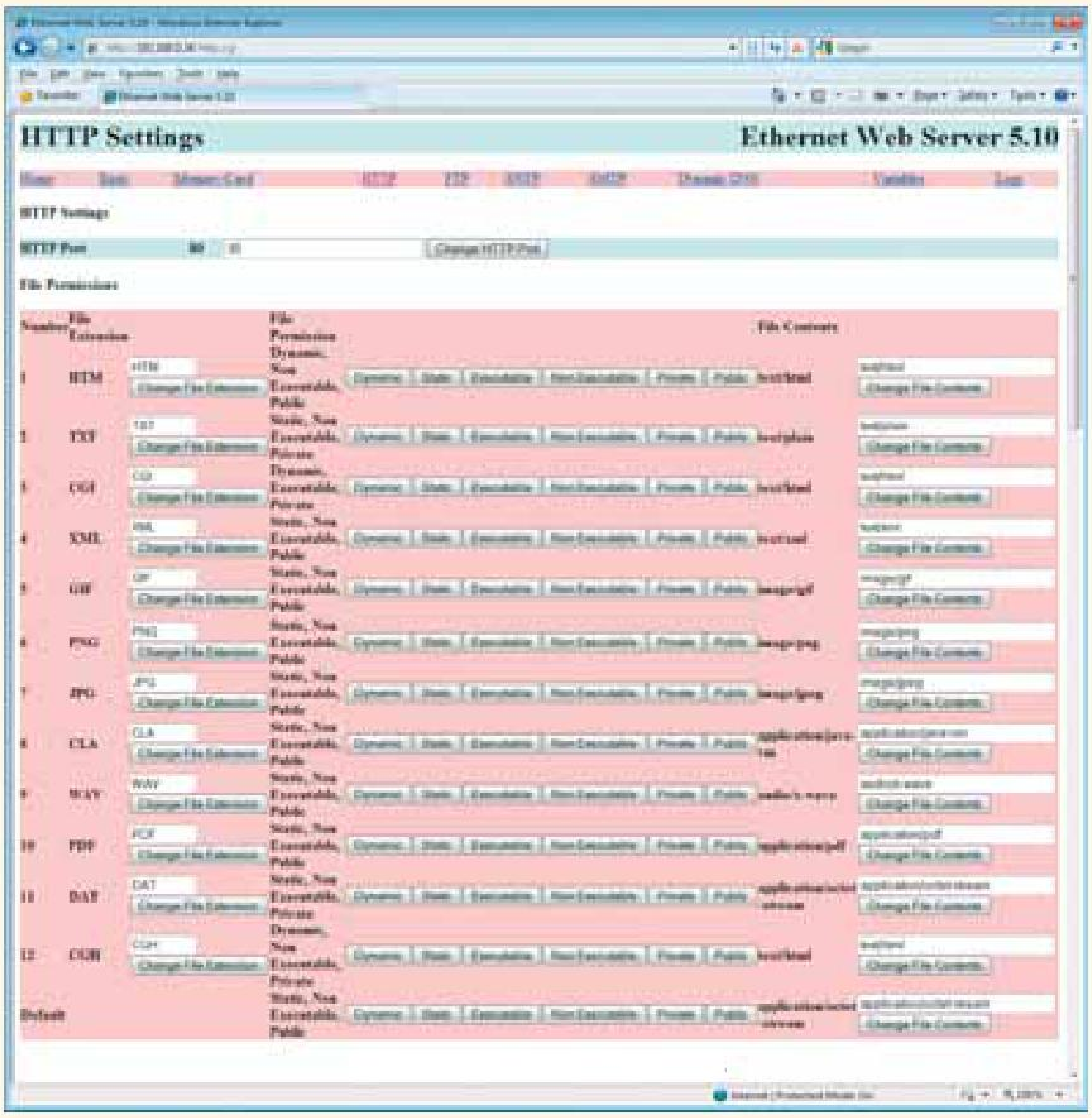
The HTTP file extension and permission settings should be modified only by *advanced users* who wish to customise the behaviour of the WIB. If necessary, you can change the HTTP port number (default 80) and the file extensions, contents and permissions to determine whether files are for public or private access.

Basically, each file that is served by the WIB is treated differently, according to its extension. If the file has one of the 12 user-defined extensions, it's assigned the corresponding user-defined file permissions and content type. If not, it's given the default content type and file permission.

The content type is specified in the HTTP header and is known as a 'MIME-file' extension. This allows non-html files to be opened in a web browser, eg, pdf and gif files. Basically, the content type affects how the browser opens, transfers and displays the file.

Note that the file permissions allocated to a particular file extension apply to all files with that file extension.

Step 6 CONTINUED . . .



HTTP Settings

Ethernet Web Server 5.10

HTTP Settings

HTTP Port 80

File Permissions

Number	File Extension	File Permission	File Contents
1	HTM	Dynamic, Non Executable, Public	text/html
2	TXT	Static, Non Executable, Private	text/plain
3	CGI	Dynamic, Executable, Private	text/html
4	XML	Static, Non Executable, Public	text/xml
5	GIF	Static, Non Executable, Public	image/gif
6	PNG	Static, Non Executable, Public	image/png
7	JPG	Static, Non Executable, Public	image/jpeg
8	CLA	Static, Non Executable, Public	application/java-vm
9	WAV	Static, Non Executable, Public	audio/x-wave
10	PDF	Static, Non Executable, Public	application/pdf
11	DAT	Static, Non Executable, Private	application/octet-stream
12	CGH	Dynamic, Non Executable, Private	text/html
Default		Static, Non Executable, Public	application/octet-stream

Fig.19: the HTTP Settings page lets you set the file permissions. Do not modify the default values unless you know exactly what you are doing.

There are three file permissions and these are as follows:

1) Public/Private: this determines whether or not a user needs to log in to access a particular file type on the WIB.

If a file type is public, then anyone can access those files without logging in. For example, if pdf files are public and there's a file on the WIB called **report.pdf**, then that file can be accessed simply by entering **IPaddress/report.pdf** in the address bar of a web browser. In this case, **IPaddress** is either the public IP address of the modem if the user is accessing the WIB via the Internet, or the fixed IP address of the WIB itself if access is via the local network (ie, **192.168.0.34/report.pdf**).

Note that because the file type is public, no log-in would be required.

Similarly, if a hostname has been assigned (as described in the Dynamic DNS section below), then the user would simply enter **hostname/report.pdf** in the address bar.

Conversely, if a file type is private, then the user will be required to log in to gain access. In fact, special system files should be made private so as to not compromise the system's security. These include the **settings.txt** file, the **log.txt** file and the **values.dat** file. All three contain password information that should not be public.

So, as a minimum, the 'txt' and 'dat' extensions should be private (ie, you should leave them at the default settings).

Note that cgi files are also made private by default. This setting should be left as it is if you intend using the website cgi files we have provided for the WIB. Alternatively, you might want to make cgi files public if you create your own web pages with active content.

As shown in Fig.19, quite a number of file types are made public by default, including pdf, jpg, gif and wav. However, you might want to change all these file types to private, so that no pages are accessible unless the user logs in using a username and password.

2) Static/Dynamic: this file permission determines whether the page contains dynamic content or fixed content. This affects whether the web server replaces dynamic content references or only serves a static page (we'll explain this next month in Part 3).

(3) Executable/Non-executable: this permission specifies whether or not you can execute the commands on html forms. This should be set to Executable for file extensions that contain (modified) CGI command references – see Part 3 next month for an explanation of how commands are implemented. Once again, the default settings will be suitable in nearly all cases.

- **SNTP Settings:** this page sets up the SNTP client so that it accesses an Internet time server (eg, to time-stamp logging entries).

The 'epoch time' is the reference for SNTP, and the 32-bit number returned as a result of a time query is the number of seconds that have elapsed since this reference time. For a typical NTP server, this is set at 00:00 on 1 January, 1970.

In order for the SNTP client to work, you must have a valid DNS server address entered in the Basic Settings. You can usually just use the Gateway Address (eg, 192.168.0.1) here, but **if the NTP client fails to pick up the correct time, use your ISP's DNS server address.**

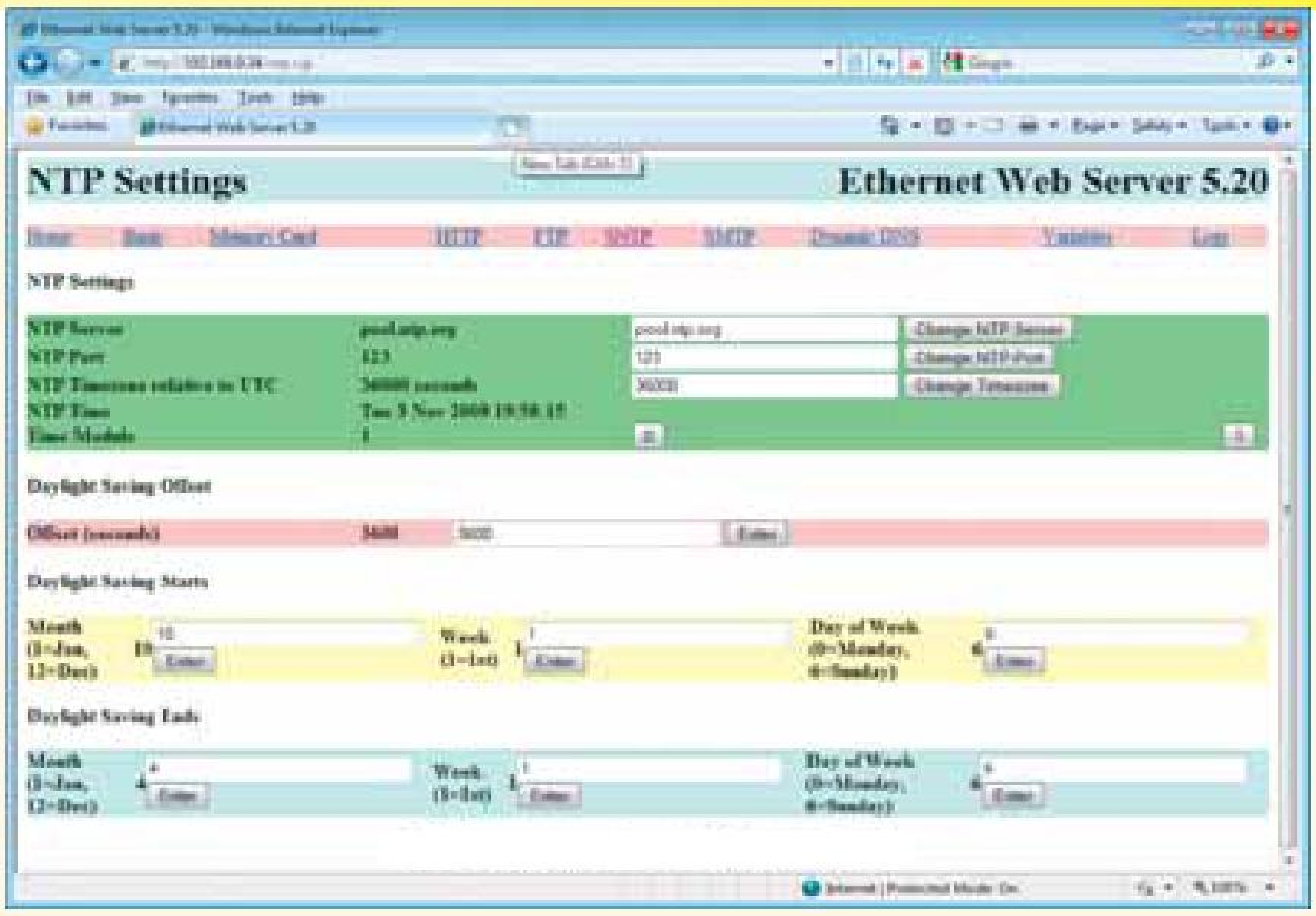
Begin by clicking on the SNTP link to bring up the page shown in Fig.20. The default time server value is **pool.ntp.org**, but there are lots of other NTP servers on the Internet, and you can change the default server to any of these. The default port number is 123. This will only need to be changed in rare circumstances, and then only if you have advanced knowledge of port forwarding.

Note that the time obtained by SNTP is UTC (Coordinated Universal Time) time. This means that you need to specify an offset value, depending on your geographical location, to convert to local time.

The east coast of Australia (Sydney, Brisbane, Melbourne) is 36,000 seconds (ie, 10 hours) ahead of UTC and so 36000 is the default value here. Adelaide and Darwin are 9.5 hours ahead of UTC, so the value to use is 34200. The offset for Perth is 25200 (ie, 7 x 60 x 60).

In practice, it's just a matter of checking how far your region is ahead of UTC time and entering the value in seconds accordingly. Note that if you live in a part of the world that is behind UTC (eg, Canada and the US), you have to specify a negative number. For example, if you are four hours behind UTC, you would specify an offset value of –14400.

Finally, the NTP page has provision for you to enter in the start and end dates for daylight saving, so that the time automatically adjusts. You also need to enter the daylight saving offset (eg, 3600 seconds for one hour). Setting this offset to '0' turns daylight saving off


NTP Settings
Ethernet Web Server 5.20

NTP Settings

NTP Server pool.ntp.org
NTP Port 123
NTP Timezone relative to UTC 36000 seconds
NTP Time Tue 3 Nov 2009 19:58:15
Time Module 1

Daylight Saving Offset

Offset (seconds) 3600

Daylight Saving Starts

Month (1=Jan, 12=Dec) 10
Week (1=1st) 1
Day of Week (0=Monday, 6=Sunday) 6

Daylight Saving Ends

Month (1=Jan, 12=Dec) 4
Week (1=1st) 1
Day of Week (0=Monday, 6=Sunday) 6

Fig.20: the default NTP server and port values will be suitable in most cases. Enter in an offset value to suit your time zone and the daylight saving details.

- **FTP Settings:** clicking the FTP link brings up the page shown in Fig.21. The default port values shown here for the FTP server (ie, 20 and 21) should generally be left as they are, but some advanced users might want to change them under certain circumstances.

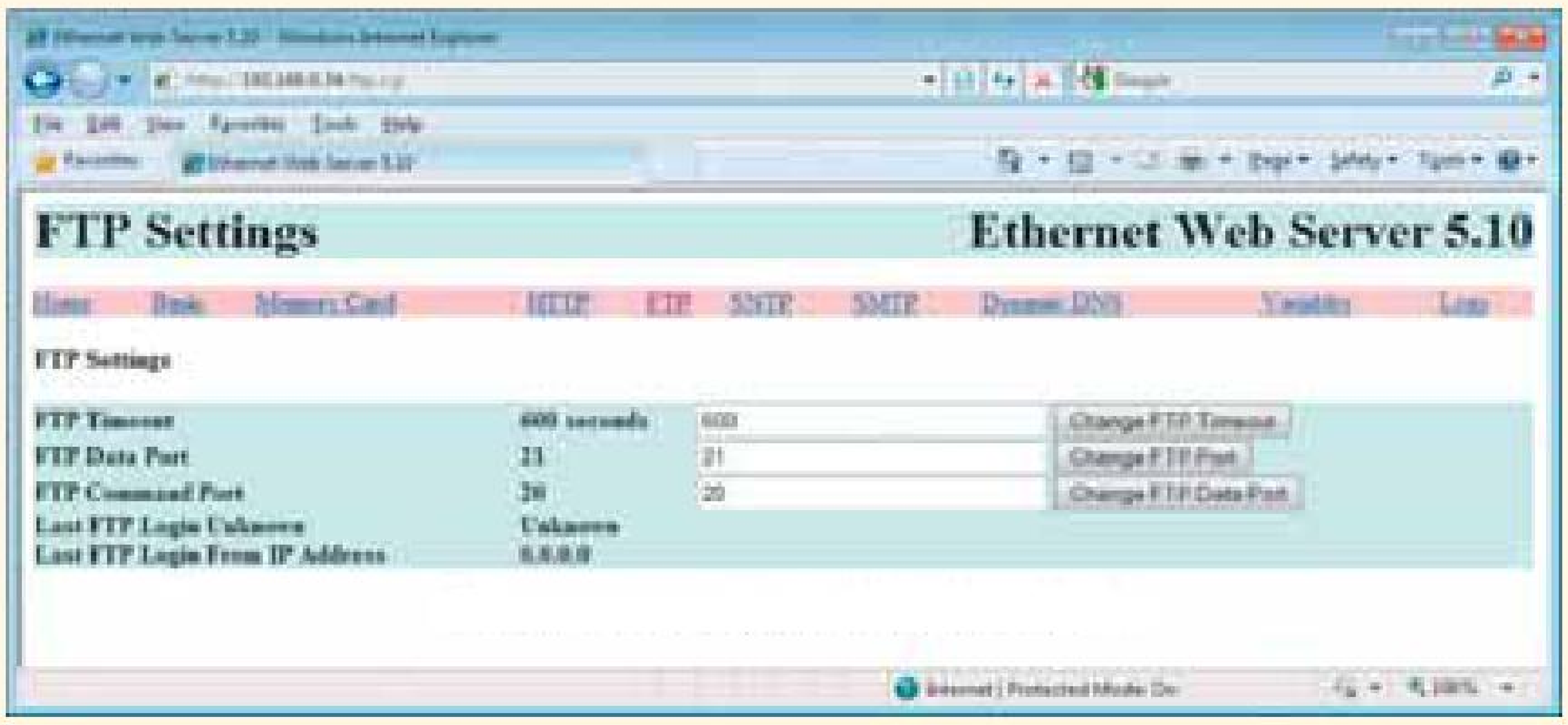
The timeout is the amount of time that is allowed to elapse without activity before the client is disconnected. This is an automatic logout in case you forget to do so. The default is 600s (10 minutes).

There are many FTP client programs for Windows and other operating systems, but many of these won't work with the WIB because it doesn't implement the full FTP command set. The way around this is to use a command line program called **ftp**. You invoke it from a command prompt simply by typing 'ftp x.x.x.x' where x.x.x.x is the IP address of the WIB.

If the IP address is valid, you will be prompted for the log-in username and password.

As stated, the WIB's FTP server only implements a subset of the full FTP command set. However, the main commands such as **get**, **put**, **cd**, **pwd**, **dir**, **delete**, **user** and **pass** are all available, as are the macro commands **mget** and **mput** (batch **get** and **put** commands respectively).

In particular, the **mput** command is useful for uploading an entire website to the WIB if you don't wish to transfer the files directly using a PC and a memory card reader.


FTP Settings
Ethernet Web Server 5.10

FTP Settings

FTP Timeout 600 seconds 600
FTP Data Port 21 21
FTP Command Port 20 20
Last FTP Login Unknown Unknown
Last FTP Login From IP Address 0.0.0.0

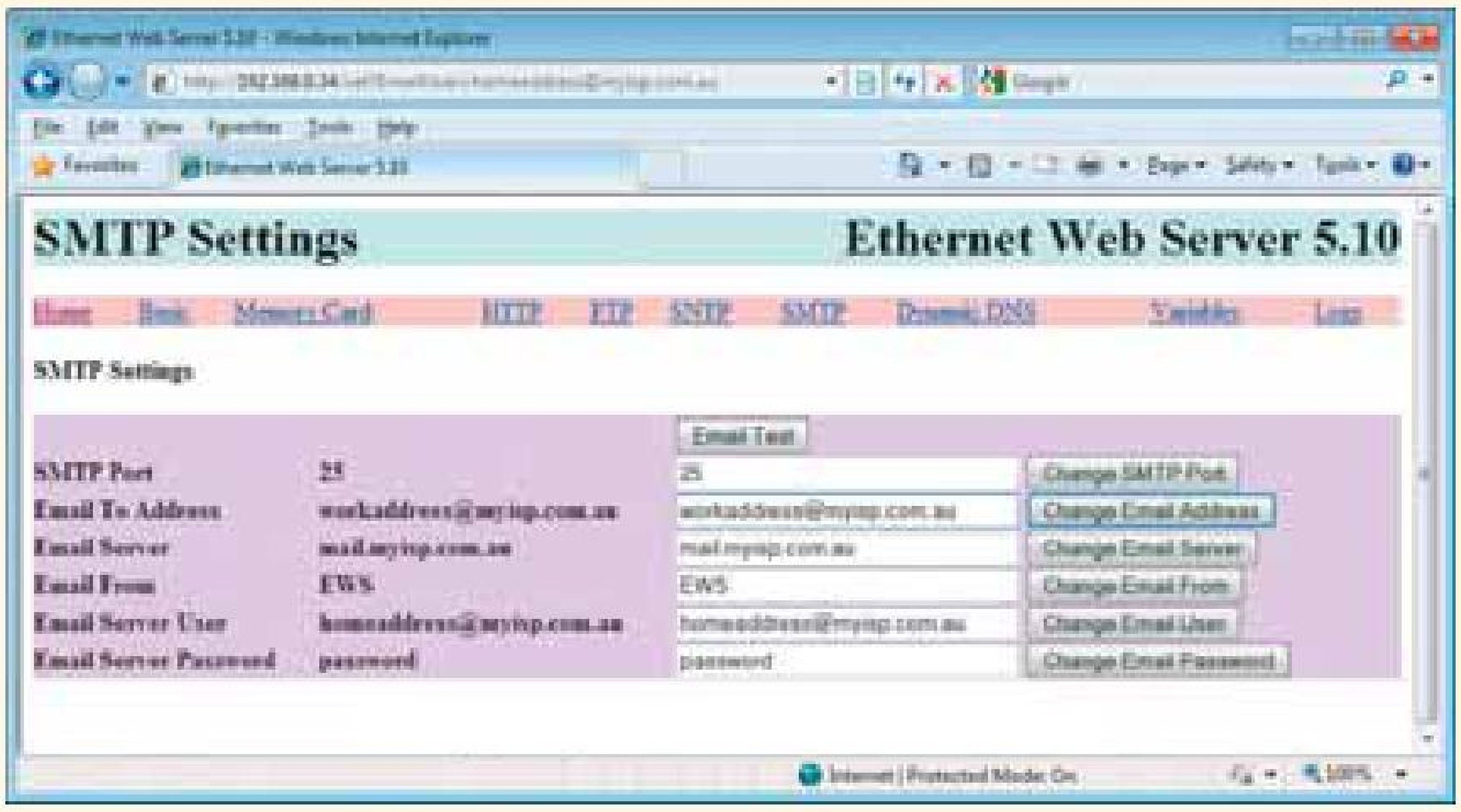
Fig.21: the default FTP setting can usually be left as they are.

Table 1: FTP commands

CD: change directory.
PWD: show the current directory.
DELETE: delete a file.
DIR: show the files in the current directory and the file sizes.
LS: show only the name of the files in the current directory.
PUT: send a file to the ethernet web server.
GET: retrieve a file from the WIB.
MGET: retrieve a collection of files from the WIB.
MPUT: send a collection of files to the Ethernet web server.
USER: specify the username for login.
PASS: specify the password for login.
OPEN: open an FTP connection to a remote server.
QUIT: exit the current FTP session.

Table 1 sets out the available FTP server commands. We'll give an example FTP session in Part 3 next month.

Step 6 CONTINUED . . .



SMTP Settings Ethernet Web Server 5.10

SMTP Settings

SMTP Port 25
Email To Address workaddress@myisp.com.au
Email Server mail.myisp.com.au
Email From EWS
Email Server User homeaddress@myisp.com.au
Email Server Password password

Home
Basic
Memory Card
HTTP
FTP
SNTP
SMTP
Dynamic DNS
Variables
Logs
Email Test
Change SMTP Port
Change Email Address
Change Email Server
Change Email From
Change Email User
Change Email Password
Internet | Protected Mode: On
100%

Fig.22: the SMTP Settings page. Click the 'Email Test' button after entering in all the details, to verify that it works.

- **SMTP (Email) Settings:** clicking this link brings up the dialog shown in Fig.22. This is where you enter your email settings, so that the WIB can send emails.

The SMTP port can be left at its default of 25, so start by entering in the address that you want the WIB to send emails to. That done, enter in the hostname of your ISP's SMTP server. For example, the Bigpond SMTP server is at **mail.bigpond.com**, while the Optus SMTP server is at **mail.optusnet.com.au**

Note that the SMTP server will be specified in your usual email client (eg, Outlook Express), so it's easy to check. Alternatively, check your ISP's website for the hostname of their SMTP server.

Next, fill in the 'Email From' field. This will typically be your name or your email address, but you can also use any other name.

Finally, enter your email username (usually your full email address) and your email server password. Don't forget to click the corresponding 'Change' button as each field is completed.

Now click the Email Test button. This allows you to check that your SMTP configuration is valid. If all is well, a test email will be sent each time you click this button and you can verify this by clicking the Basic link and scrolling to the bottom of the system log on that page (note: you may have to reload the page to update the log file from the version cached by your browser).

If it doesn't work, try resetting the WIB after changing the SMTP settings to ensure that the changes have taken effect. This is done by clicking the 'Master Reset' button on the Basic page, or you can restart the WIB by switching it off and on.

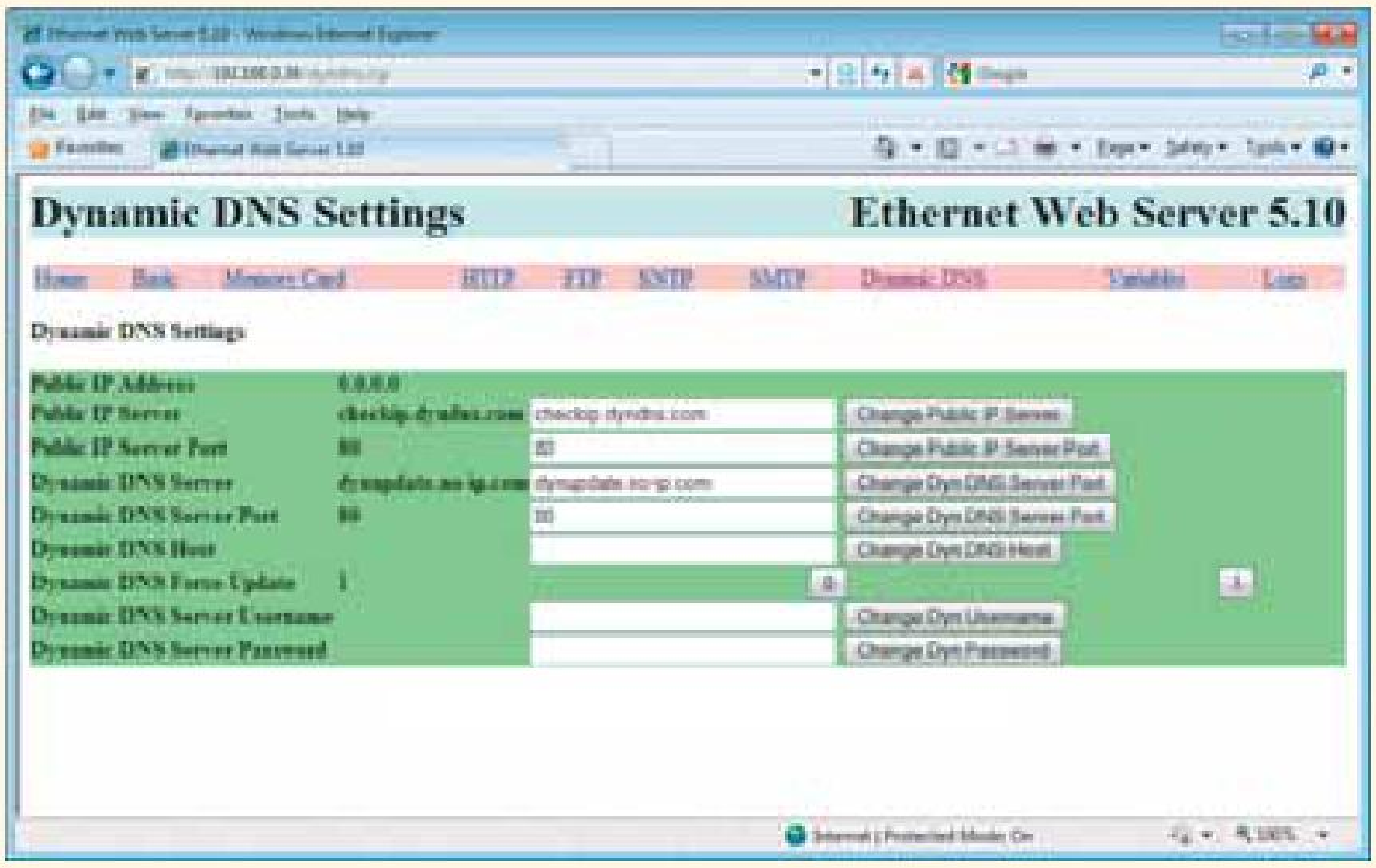
Note that an error code is returned on each failed email attempt and this is useful for debugging.

Once you've got it working, the WIB will start sending email notifications as follows:

a) Each time a master reset is performed
b) When the IP address of the WIB is changed
c) When an analogue input breaches its set limits
d) Periodically (if enabled) when the required number of log entries is reached.

- **Dynamic DNS Settings:** although the IP address of the WIB itself is fixed (eg, to 192.168.0.34), its public IP address (ie, that presented to the outside world by your modem) may change. This is because most ISPs assign dynamic IP addresses for specific 'lease' periods (eg, 12 hours) rather than hand out static addresses. This is a way of making the most of the limited range of IP addresses assigned to a particular ISP.

Because the public IP address assigned by your ISP may change, and since this address must be used to access the WIB from anywhere outside your home network, we need a way to automatically keep track of any address changes. A common method for doing this is called 'Dynamic DNS' (Dynamic Domain Name System).



Dynamic DNS Settings Ethernet Web Server 5.10

Dynamic DNS Settings

Public IP Address 0.0.0.0
Public IP Server checkip.dyndns.com
Public IP Server Port 80
Dynamic DNS Server dynupdate.no-ip.com
Dynamic DNS Server Port 80
Dynamic DNS Host
Dynamic DNS Force Update 1
Dynamic DNS Server Username
Dynamic DNS Server Password

Home
Basic
Memory Card
HTTP
FTP
SNTP
SMTP
Dynamic DNS
Variables
Logs
Change Public IP Server
Change Public IP Server Port
Change Dyn DNS Server Port
Change Dyn DNS Server Port
Change Dyn DNS Host
0
1
Change Dyn Username
Change Dyn Password
Internet | Protected Mode: On
100%

Fig.23: the Dynamic DNS Settings page requires entries for the public IP server and the dynamic DNS server.

This is a service that keeps track of a dynamic IP address by associating it to a static hostname. For example, you could associate the hostname **silchip.redirectme.net** to your current dynamic IP address and the system

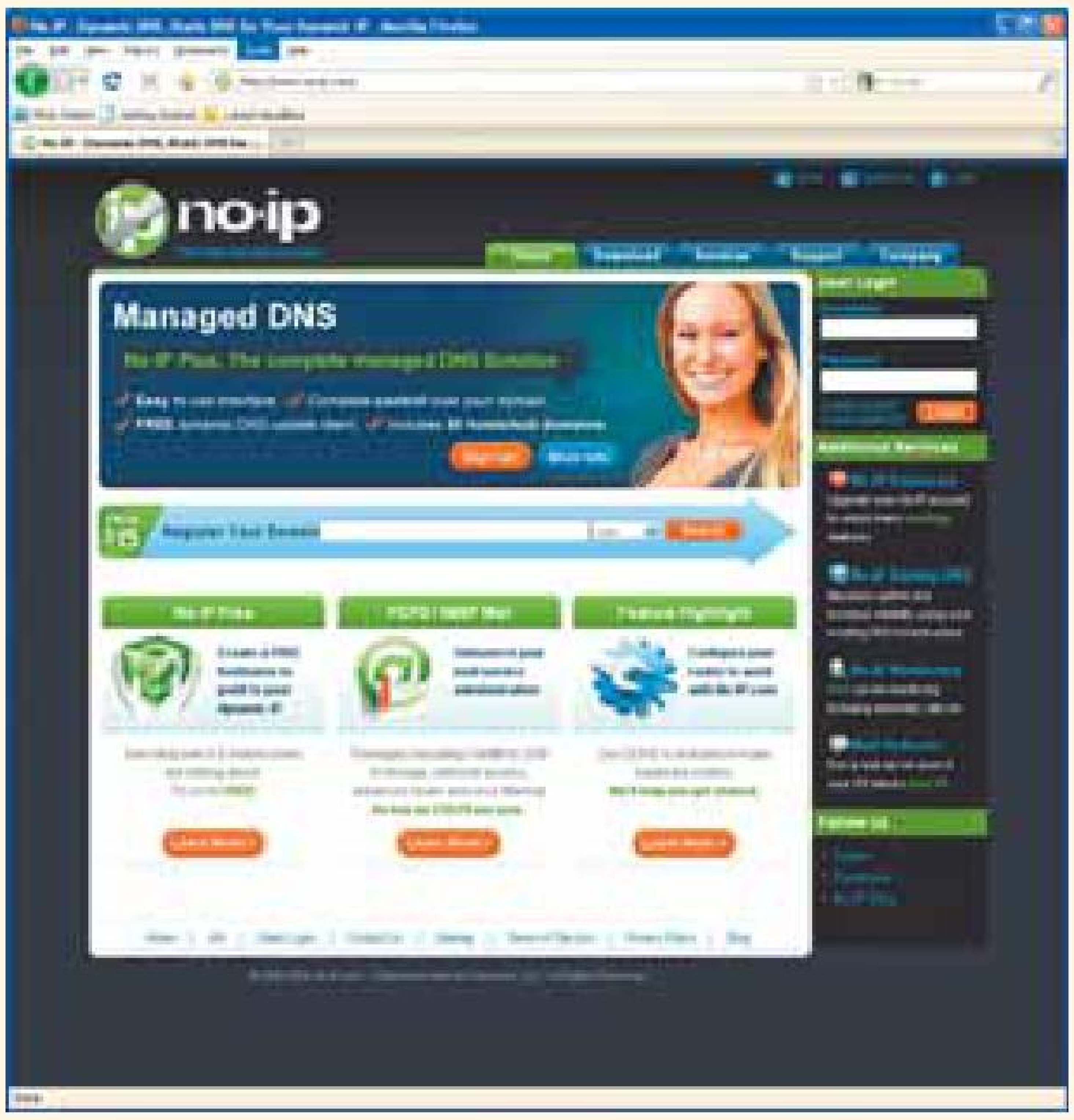


Fig.24: you can set up a dynamic DNS service for the WIB by pointing your web browser to www.no-ip.com

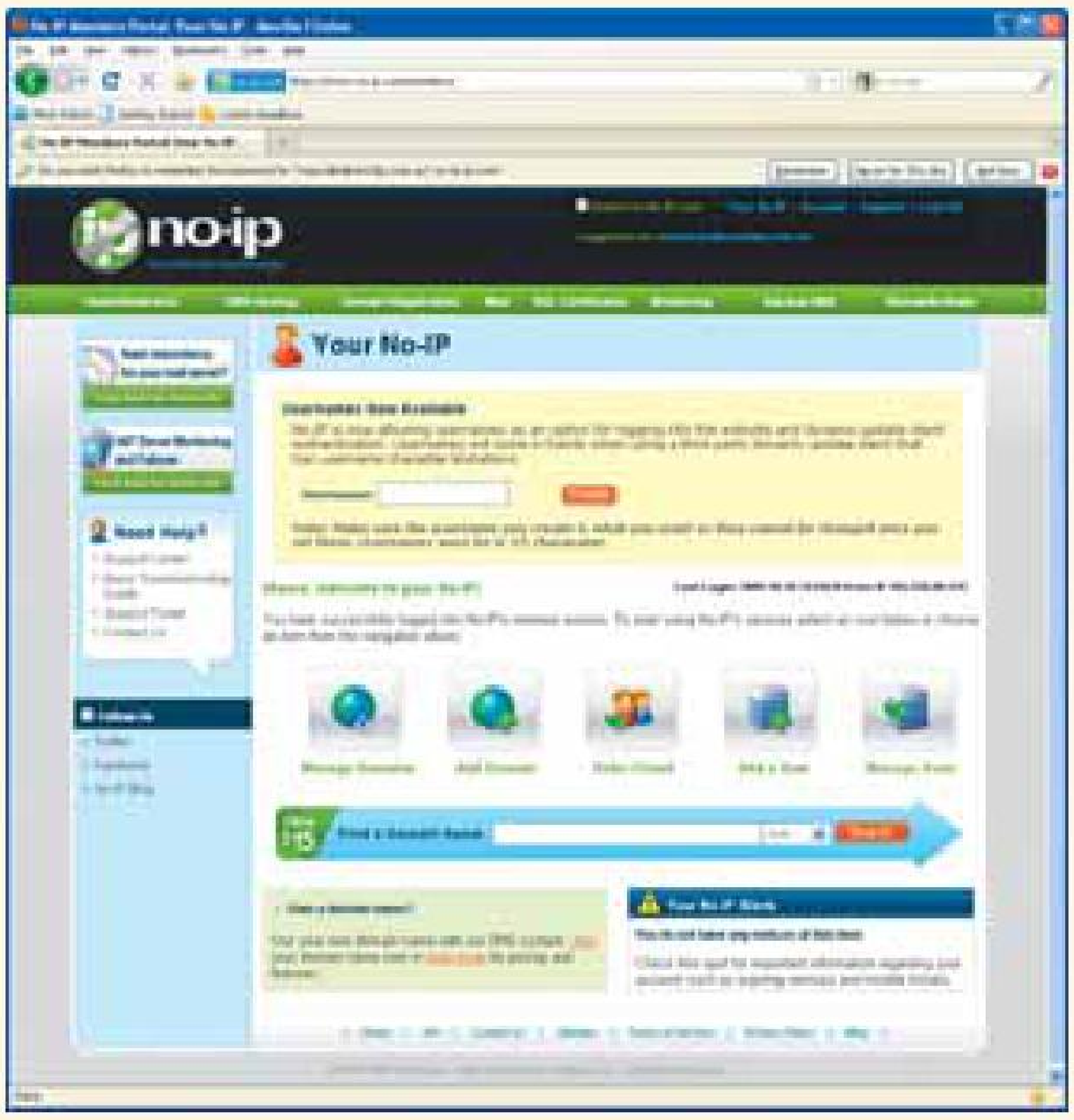


Fig.25: once you've created an account, log go to www.no-ip.com/members and click the 'Add A Host' button.

will then automatically track any future changes.

This is exactly what we need for the WIB so that it can be accessed from the Internet by using its hostname rather than its public IP address.

Dynamic DNS will work with a static IP address too. However, in this case, it would not have to keep track of any IP address changes. Instead, you would use the DNS service simply for the convenience of being able to use a hostname rather than an IP address.

A dynamic DNS client is built into the WIB, so setting up the service is straightforward. The first step is to set up an account with a dynamic DNS provider at either **www.no-ip.com** or **www.dyndns.com**. You will need to sign up to a free account at one of these.

Once that is done, the WIB will automatically log into your account on a regular basis. It will then update its public IP address on the service if it detects it has changed. There may be a delay of up to 10 minutes until the changes are fully propagated but once they are, you will be able to again access the WIB using its fixed hostname.

Note that many modem/routers also include a dynamic DNS client. In practice, you could use this instead of the one in the WIB, but we'll assume here that you'll be using the latter.

OK, let's take a look at how you would go about setting up an account at **www.no-ip.com**

Begin by pointing your web browser to **http://www.no-ip.com** and click the green **No-IP Free** button – see Fig.24. Type in your email address and click the 'Sign Up Now' button, then follow the prompts to create your account. Once you've created your account, log in by going to **www.no-ip.com/members**

Your home page will look something like Fig.25.

Now click on the 'Add A Host' button, type in a hostname of your liking and choose a domain from the list of available names. For example, we chose **silchip** for the name and **redirectme.net** for the domain to get the hostname **silchip.redirectme.net**

Now click on the 'Create Host' button to complete setting up the dynamic DNS host.

Having created the host account, the WIB must now be set up to log into this account when it detects a change in its public IP address. This is done by first clicking on the Dynamic DNS link to bring up the page shown in Fig.23.

A number of settings now need to be entered in the **Dynamic DNS Settings** page, beginning with the public IP server. This is basically an HTTP server that allows you to determine your current public IP address (ie, as assigned by your ISP).

A suitable public IP server is at **checkip.dyndns.com** and this is the default (note: IP servers that return a full html page, such as **whatismyip.com**, cannot be used).

Do you really need Dynamic DNS?

It's not always necessary to set up a dynamic DNS service. In particular, if you have been assigned a static IP address by your ISP, then the WIB can always be accessed over the Internet using this fixed public address.

Similarly, if you have a dynamic IP address, this is unlikely to change if the modem is permanently powered up. And even if the modem is switched off for a short time or there is a power interruption, it will be assigned its previous IP address provided it is within the lease period. So again, depending on you application, you might not want to bother setting up a dynamic DNS.

Step 6 continued...

To check this, enter **checkip.dyndns.com** in the address field of your browser. You should receive a simple html file response containing your public IP address. It will look like this:

```
Current IP Address: 165.221.92.134
```

except the IP address will almost certainly be different (ie, it will show your current public IP address).

So that's how the WIB determines its public IP address. This discovered address is displayed on the Dynamic DNS Settings page (Fig.23).

The public IP server port should be set to 80, which again is the default (it can be changed if necessary by advanced users).

For the Dynamic DNS server, you have to enter the hostname of the server for the particular account you've just created. If you are using the service at **www.no-ip.com**, enter **dynupdate.no-ip.com** as the server. Alternatively, if you are using the service at **www.dyndns.com**, you should enter **members.dyndns.org**.

The dynamic DNS server port should normally be left at 80 (the default). You should set force updates to 1 and then enter the username and password to log into the account you created with your dynamic DNS provider.

That completes the dynamic DNS set-up. You should now be able to use the hostname to browse the website on the memory card from anywhere on the Internet. In our case, we chose **silchip.redirectme.net** as the hostname, so the home page can now be accessed from the Internet by entering **silchip.redirectme.net/home.cgi** in a browser and logging in.

That's easier to remember than using **165.221.92.134/home.cgi** to access the WIB.

Step 7: Configure the analogue variables

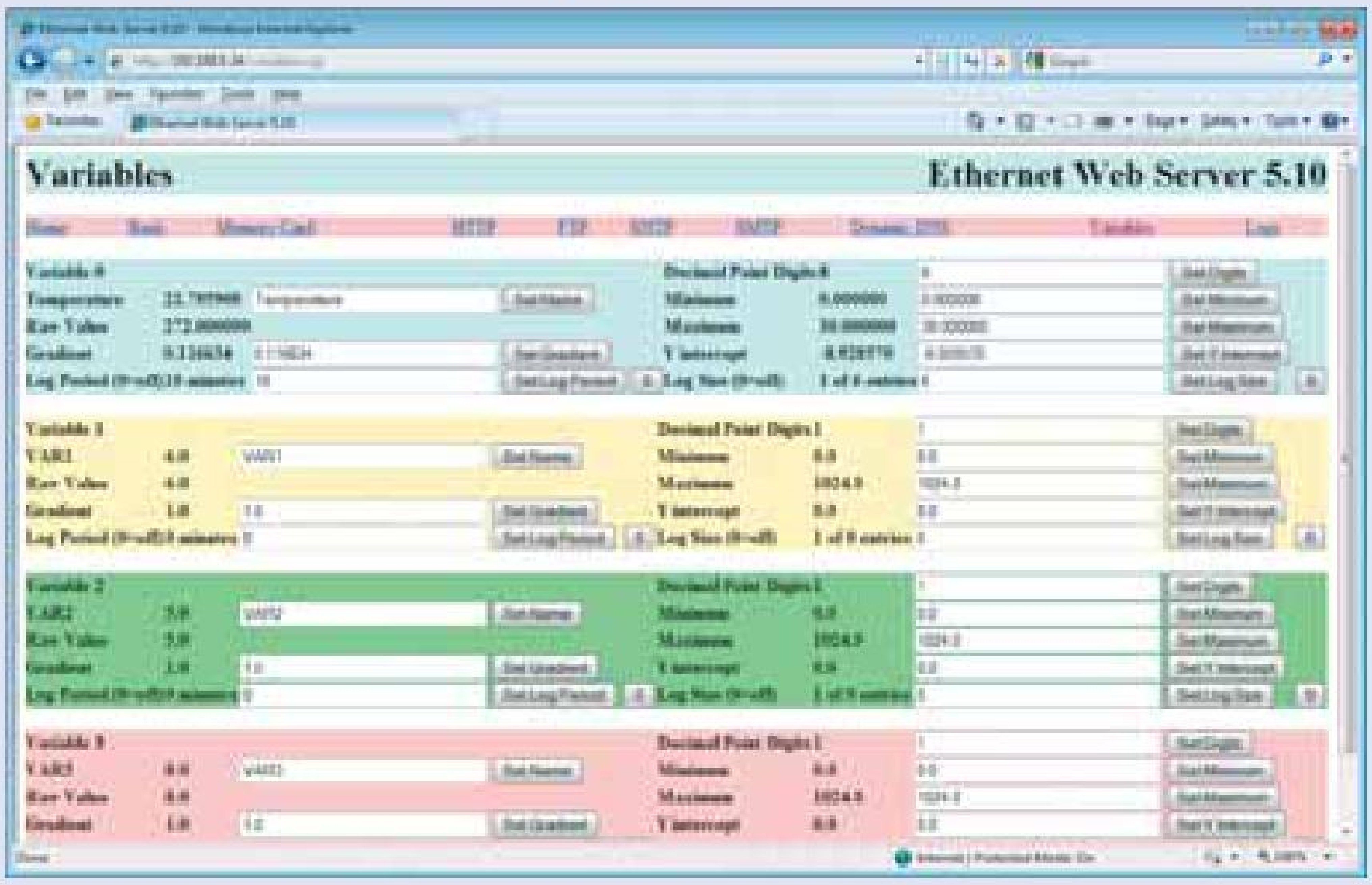


Fig.26: the Variables set-up page allows you to define and set up the various parameters (including minimum and maximum limits) for the four analogue inputs. In this case, we have set up a temperature sensor on Variable 0.

FIG.26 SHOWS the analogue variables set-up page. This has fields for each of the four analogue inputs (ie, Variable 0 to Variable 3). You only have to enter data for the sensors used. For example, if you have a temperature sensor connected to input AN0 (pin 9 of CON3), then you only have to enter data into the Variable 0 fields.

Before going further though, we'll make it easy for you. **If you are using the AD22103 temperature sensor, enter a value of 0.11663409 into the Gradient field and –8.928571429 into the Y-intercept field. It's then just a matter of entering the number of decimal points, the minimum and maximum limits for email notification (see below), the logging period and the number of logging entries.**

Let's look at all this in greater detail. The Raw Value is the digitised ADC (analogue-to-digital converter) value. This value will be between 0 and 1023 (inclusive), as this is a 10-bit conversion. Remember that the voltage range will be from 0V (GND) to 3.3V (ie, the 3.3V rail voltage).

If the sensor has an output voltage range greater than this, you will need to add a voltage divider (consisting of two resistors) to bring the voltage fed to the WIB's input back within the 0V to 3.3V range. This is then taken into account when 'calibrating' the sensor by setting the gradient and y-intercept values in the WIB.

From the raw value, the actual value of the input variable is calculated using the gradient and y-intercept values as follows:

$$\text{value} = \text{gradient} \times \text{raw} + \text{y-intercept}$$

This means that, in order for readings to be accurate, you will need to enter the correct gradient and y-intercept values for the particular sensor being used (note: we are assuming that the sensor has a linear response).

Let's consider the AD22103 temperature sensor, for example. This can measure temperatures ranging from 0-100°C and its output is 'ratiometric'.

From the data sheet, its output voltage (Vo) is given by the formula:

$$V_o = (V_s/3.3) \times (0.25 + 0.028 \times T) \qquad (1)$$

where Vs is the actual supply voltage to the sensor (slightly less that 3.3V because of the series 110Ω resistor) and T is the temperature (0-100°C).

As stated, the raw value is the ADC value and is determined by the equation;

$$\text{raw} = (V_o/V_{dd}) \times 1023 \qquad (2)$$

where Vdd is the actual voltage of the 3.3V supply rail.

Rearranging and plugging this into equation 1 gives the temperature as a function of the raw value:

$$T = (3.3 \times Vdd)/(Vs \times 1023 \times 0.028) \times raw - (0.25/0.028)$$

or

$$T = (0.1152073733 \times Vdd/Vs) \times raw - 8.928571429$$

In practice, Vs will be about 3.23V, while Vdd will be about 3.27V. Therefore, the correct values for the gradient and Y-intercept for this temperature sensor are:

1) Gradient = 0.11663409
2) Y-intercept = –8.928571429

These values must be entered in the Variable 0 gradient and Y-intercept fields respectively (assuming the sensor is connected to AN0).

You can also enter in minimum and maximum limits for the sensor. When these limits are breached, an email is sent automatically. If the measured value drops below the minimum limit, the file **var0min.txt** appears in the email body. Conversely, if the maximum limit is exceeded, **var0max.txt** is included.

For Variable #1, the corresponding files are **var1min.txt** and **var1max.txt** and so on.

Note that a 10% limit value hysteresis is included in the firmware to prevent too many emails from being sent in a short time, eg, if the temperature is fluctuating about a limit.

You can also enter the name of the variable being monitored. For example, if you have a temperature sensor connected to Variable #0 (AN0), you can give it the name ‘Temperature’. This name will then be used in the log file and will also be referred to in any limit condition email messages.

The Log Period field lets you enter a number that sets the logging interval in minutes (0 = logging off). The system adds to the log until the number of log entries reaches the number entered in ‘Set Log Size’ field. At this point, the log file is automatically emailed to the specified email address and then cleared, ready for the next logging cycle.

For example, suppose the Log Period is set to 10 minutes and the Log Size is set to 144. The input value will be logged every 10 minutes (along with the time of day) and after 144 such entries the whole log will be emailed and then cleared. As a result, an email containing the logged entries will be sent once every 24 hours.

Similarly, setting the Log Period to 10 minutes and the Log Size to 12 will result in the log being emailed every two hours.

Finally, you can edit the text in the various ‘.txt’ files to suit your application and the content is dynamic, ie, a number of variables can be included. When the email is sent, the system replaces these variables with the relevant information.

For example, the content of **var0max.txt** is as follows:

The ~1E is currently at ~D0 which is above the set maximum of ~1C! This is an automatically generated message, created on ~E2.

In this case, 1E is the name of Variable #0 (‘Temperature’ in our case), D0 is the current value of Variable #0, 1C is the maximum limit set for Variable #0 and E2 is the current time. So, for example, the actual message that’s sent could be:

The temperature is currently at 31.0 which is above the set maximum of 30.0!

This is an automatically generated message, created on Fri 28 August 2009 17:00:00.

We’ll describe this in greater detail next month and post a table listing the dynamic page content codes on our website.

Step 8: Create the new defaults

THIS FINAL step is short and sweet! Once you’ve made all the changes to the settings, go to the Basic page of the supplied website and click on the *Create Defaults* button. This will make your settings the new defaults and create a new ***settings.txt*** file with these new defaults.

That completes the set-up of the WIB. Next month, we’ll describe the special system files that make up the website and also briefly describe how to design your own website with active content.

Network addresses

If your modem/router uses a 10.x.x.x private (ie, inwards facing) IP address, then you should change the IP address of the WIB to suit this network – eg, to 10.0.0.34 if the network is 10.0.0.x.

That’s done by editing the settings.txt file on the memory card as described in Step 5. All other settings, including the DHCP range, the Gateway address and the primary DNS address should also be changed accordingly.

Accessing the WIB’s website from the Internet

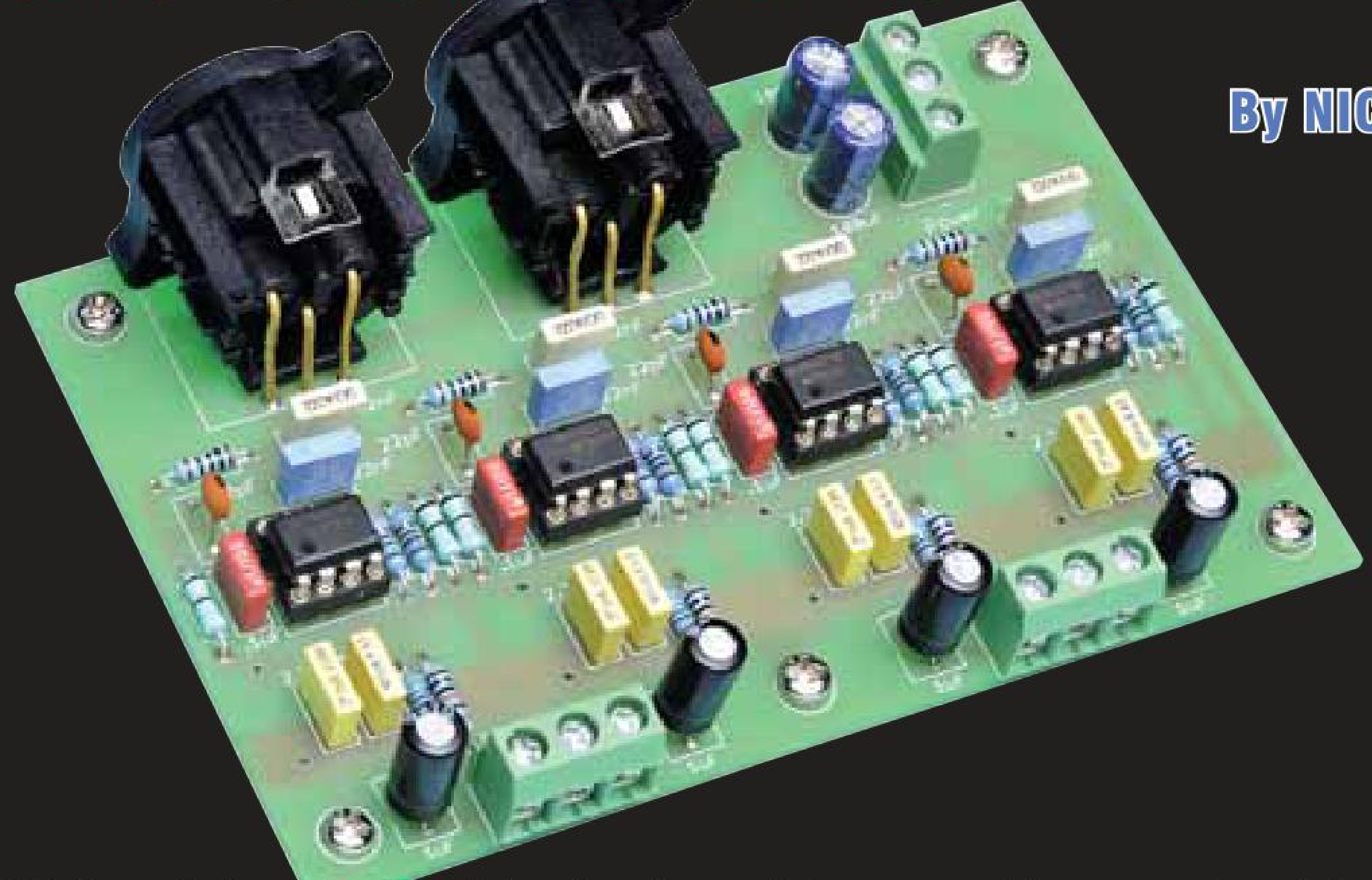
Inside your home network, you can access the WIB home page simply by entering 192.168.0.34/home.cgi in the address field of your web browser and then logging in.

Accessing the WIB’s website is just as easy from anywhere on the Internet. First, you can access it by using its public IP address; eg, 165.221.92.134/home.cgi Alternatively, if you’ve set up dynamic DNS as described in Step 6, you will be able to access it by using the hostname defined in your dynamic DNS account. In our case, the hostname is silchip.redirectme.net and so we can access the WIB using the address silchip.redirectme.net/home.cgi

Alternatively, you can go to another page (not necessarily in the root folder) by using a forward slash and the filename. For example, if we want to access a file named mydocument.doc in a sub-folder called documents, we enter silchip.redirectme.net/documents/mydocument.doc in the address field of the browser.

Of course, this also works inside your local network, ie, we would enter 192.168.0.34/documents/mydocument.doc into the browser. Note that you can not access the WIB using the hostname from inside the network.

A balanced output board for the Stereo DAC



By NICHOLAS VINEN

This add-on board is designed to provide a pair of balanced audio outputs for the High-Quality Stereo DAC (Sept to Nov 2011). Two 3-pin male XLR connectors are used for the new outputs and they can either replace or augment the existing unbalanced outputs without affecting their performance.

BALANCED AUDIO is used in recording studios and on stage because of its improved noise immunity. This is due to the fact that the signal is sent differentially (ie, as two signals 180° out of phase) and then converted to a single-ended voltage signal at the far end.

If any noise is picked up in the cable, it affects the two out-of-phase signals equally, so that when the signals are subsequently subtracted, most of the noise is eliminated.

In addition, the DAC's performance at the balanced outputs generally exceeds that of the unbalanced outputs, although only by a small margin. The signal-to-noise ratio, frequency response and channel separation are all better, although we measured a tiny bit more distortion from the balanced outputs. However, both levels are so low as to be almost negligible.

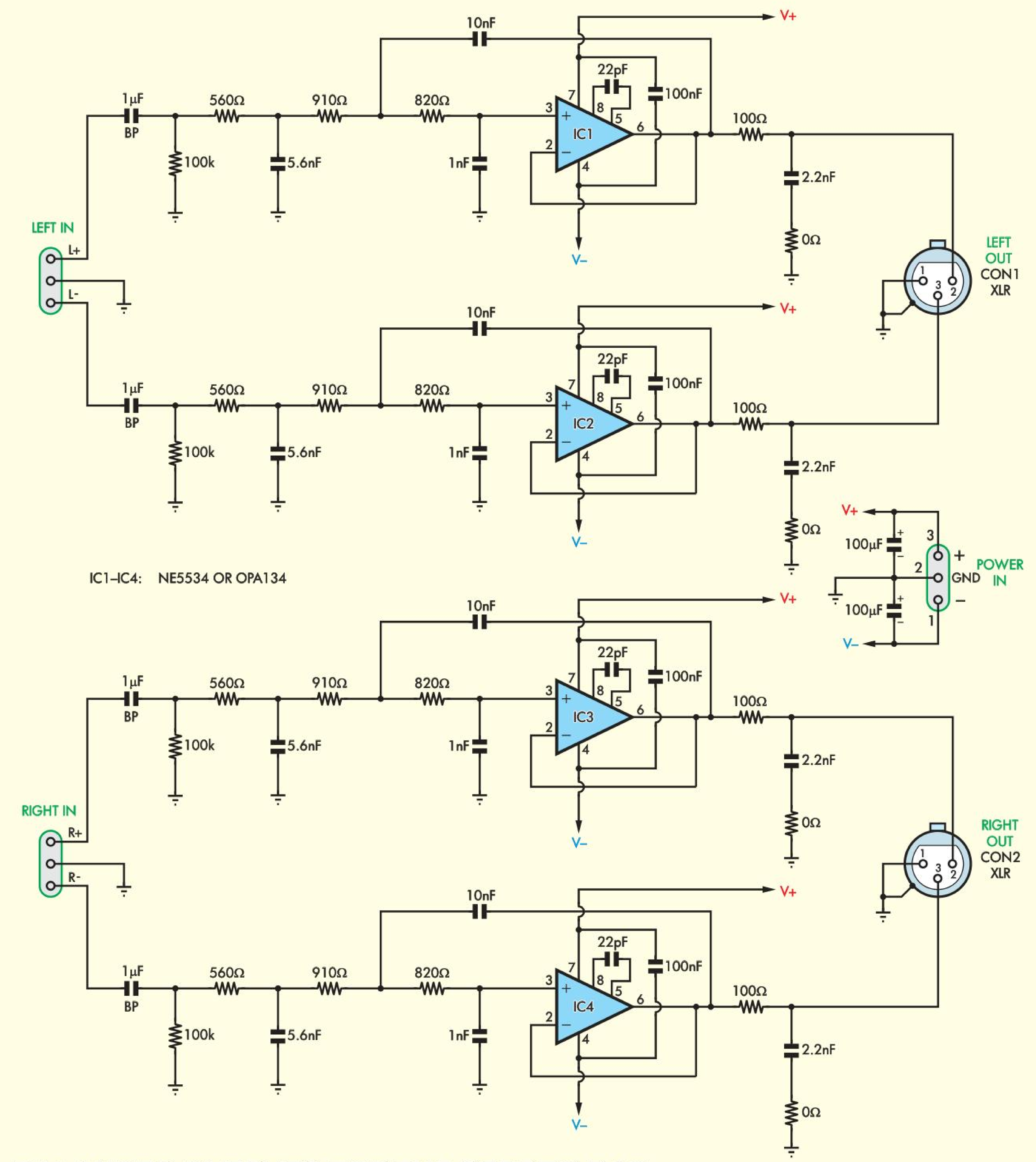
Table 1: Balanced/unbalanced output performance comparison

Measurement	Unbalanced	Balanced
THD+N, 1kHz	0.00090%	0.00095%
SNR (unweighted)	–108dB	–112dB
SNR (A-weighted)	–114dB	–116dB
Frequency response, 20Hz to 20kHz	+0, –0.15dB	+0.02, –0.05dB
Channel separation @ 1kHz	–105dB	–115dB
Channel separation @ 20kHz	–73dB	–111dB

Performance

At this point, it is worth mentioning that during the development of this board, we used a new source of digital sinewave data for distortion measurements. This revealed that the DAC is capable of lower distortion than originally quoted. With a 44.1kHz 16-bit computer-generated sinewave, the THD+N at 1kHz is 0.0012%, and with a 48kHz 20-bit sinewave the THD+N is 0.0009%.

These measurements are only slightly higher than the distortion measured directly from the Audio Precision System One's internal sinewave generator (0.0006%) so it's hard


10nF
V+
22pF
100nF
1µF
BP
560Ω
910Ω
820Ω
100k
5.6nF
1nF
IC1
IC2
IC3
IC4
100Ω
2.2nF
0Ω
V–
LEFT IN
L+
L-
LEFT OUT
CON1
XLR
RIGHT IN
R+
R-
RIGHT OUT
CON2
XLR
IC1–IC4: NE5534 OR OPA134
100µF
POWER IN
GND
+
–

BALANCED OUTPUTS FOR THE STEREO DAC

Fig.1: the incoming differential signals from the the DAC Board are fed to separate passive high-pass filter stages and then to four active low-pass filter stages based on op amps IC1 to IC4. These op amps then drive pin 2 and pin 3 of the XLR output sockets via passive low-pass filters based on 100Ω resistors and 2.2nF capacitors.

to say exactly what the actual level of distortion is. However, we can safely say it is very low indeed.

Table 1 shows a performance comparison between the balanced and unbalanced outputs, measured with the new 48kHz 20-bit sinewave source.

Note that although the channel separation from the balanced outputs is much better than that from the unbalanced outputs, in practice 73dB is more than adequate. In fact, it's very unlikely that anybody can hear the difference under normal circumstances.

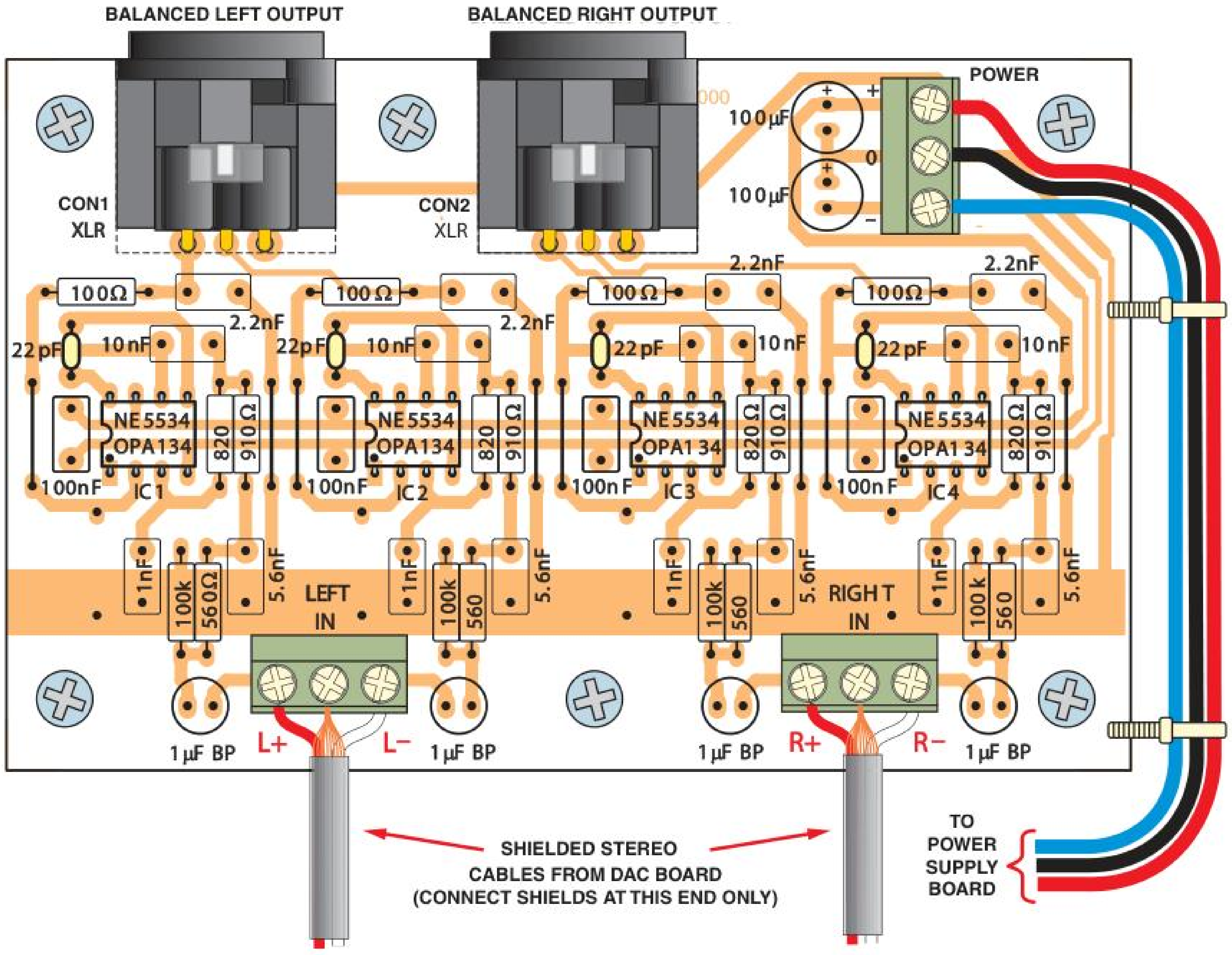

BALANCED LEFT OUTPUT
BALANCED RIGHT OUTPUT
POWER
CON1 XLR
CON2 XLR
100µF
100µF
0
2.2nF
100Ω
22pF
10nF
NE5534 OPA134
820
910Ω
100nF
IC1
IC2
IC3
IC4
1nF
100k
560Ω
5.6nF
LEFT IN
RIGHT IN
1µF BP
L+
L–
R+
R–
SHIELDED STEREO CABLES FROM DAC BOARD (CONNECT SHIELDS AT THIS END ONLY)
TO POWER SUPPLY BOARD

Fig.2: follow this parts layout diagram to assemble the Balanced Output Board. The L+, L–, R+ and R– inputs are derived from the DAC Board (see below).

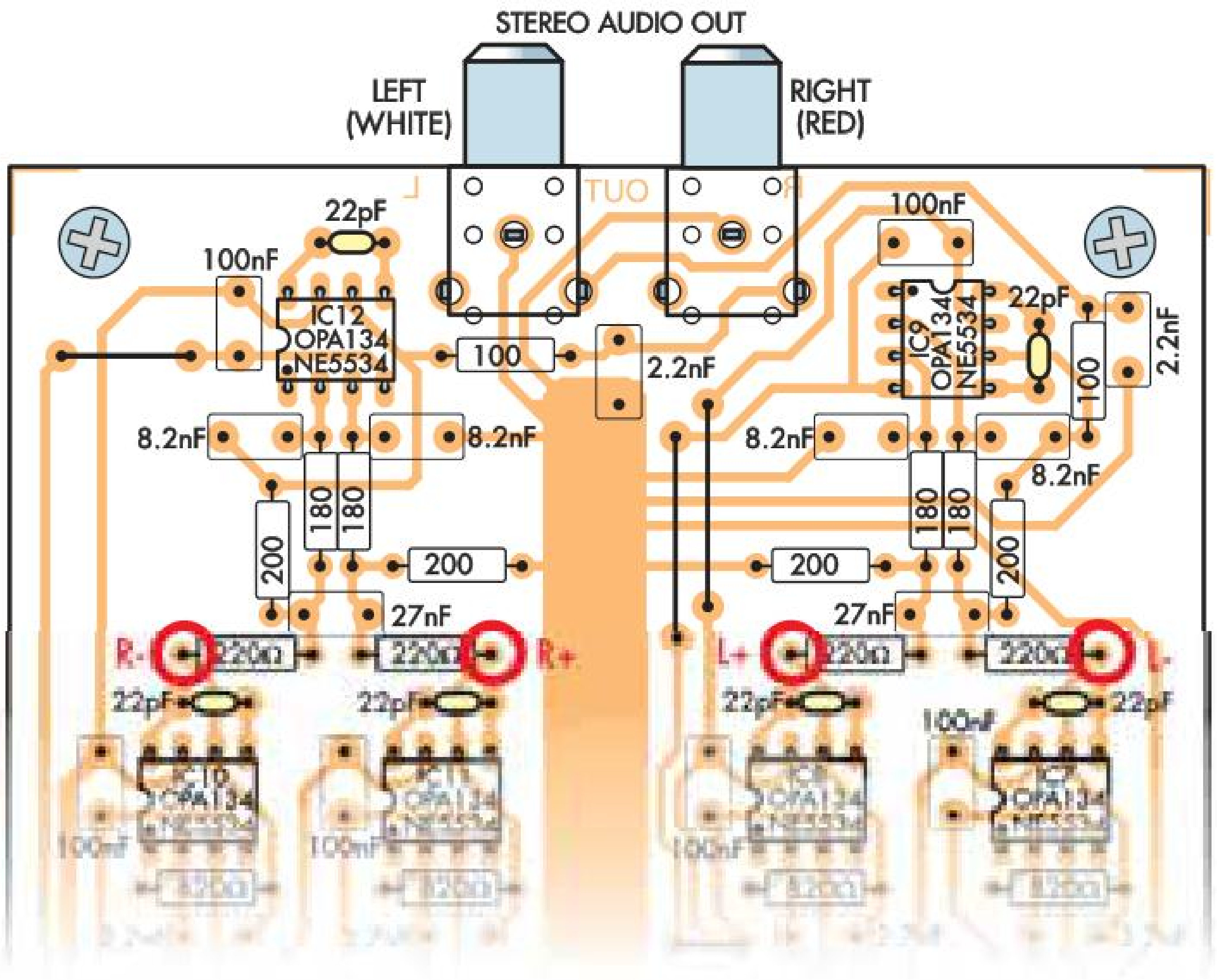

STEREO AUDIO OUT
LEFT (WHITE)
RIGHT (RED)
22pF
100nF
IC12 OPA134 NE5534
IC9 OPA134 NE5534
100
2.2nF
8.2nF
180
200
27nF
220Ω
R-
R+
L+
L-

Fig.3: the L+, L–, R+ and R– points on the DAC Board are marked here in red and drive the inputs of the Balanced Output Board. Note that the parts on the right-hand side of this board drive the left channel output socket, and vice versa.

Deriving balanced outputs

In practice, providing balanced outputs from the DAC is relatively straightforward, since the DAC chip we used – the DSD1796 – itself has balanced outputs. These are converted to single-ended signals on the DAC board via a pair of differential amplifiers (IC9 and IC12 on Fig.3, September 2011). This means that the simplest way to provide balanced outputs is to directly tap the signal going to these differential amplifiers.

Theoretically, the outputs from the current-to-voltage (I/V) converter stages (ICs 7, 8, 10 and 11) could be connected directly to the XLR socket outputs via 100Ω isolating resistors. However, we have come up with a more complicated design for a couple of reasons.

First, making a direct connection from the existing DAC board to the XLR sockets would bypass some of the low-pass filtering. This filtering is important because it's designed to remove high-frequency switching artefacts.

Second, a direct connection would load the I/V converter stages even more than they already are. In view of this, asking the op amps to drive an additional, unknown amount of cable capacitance seems unwise.

As a result, we feed the signal at the outputs of the I/V converter stages to an interface board to provide the balanced outputs. This board also includes four active low-pass filter stages based on NE5534 op amps.

Note that because the DAC's outputs are asymmetric (they only sink current), the outputs of the I/V converters (ICs 7, 8, 10 and 11) are always above 0V. As a result, these outputs are AC-coupled to the op amps in the balanced output stages to remove the DC component of the signal, so that it is centred around 0V.

Circuit details

Refer now to Fig.1 for the circuit details. It consists of two identical sections, one for each channel.

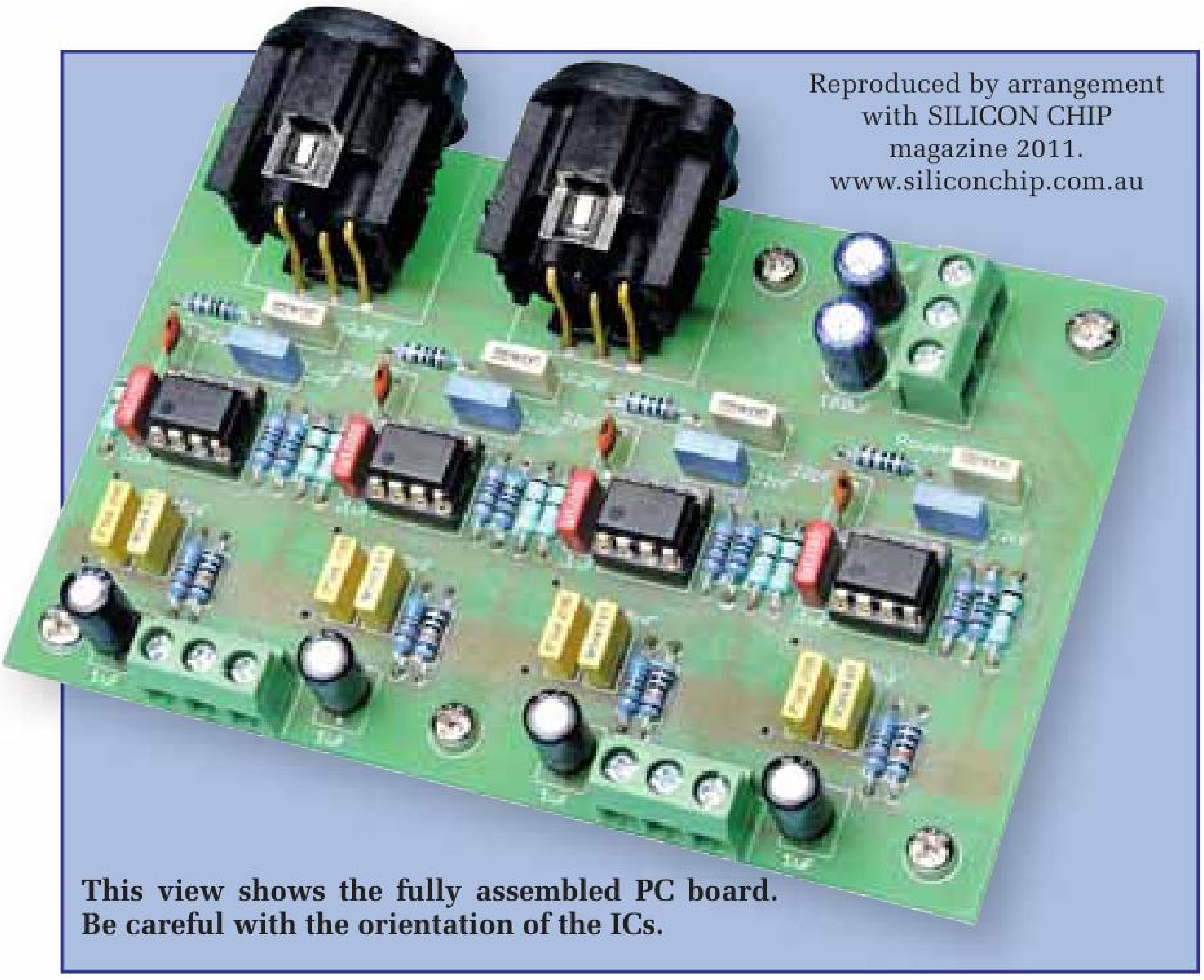
As mentioned earlier, the incoming differential signals are AC-coupled via 1µF bipolar capacitors. These capacitors and the following RC components also form 6dB/octave high-pass filters. We have set the corner frequency of this filter low enough (1.6Hz) so that it has minimal effect on the 20Hz to 20kHz frequency response (–0.046dB).

The remainder of the circuit consists mainly of the four active low-pass filter (LPF) stages, and these are based on op amps IC1 to IC4. Each filter is an active third-order LPF, with a –3dB point (corner frequency) of 52kHz and a slope of –18dB per octave. These are then followed by passive first-order 720kHz LPFs, each based on a 100Ω current-limiting resistor and a 2.2nF capacitor.

These are identical to those used at the outputs of IC9 and IC12 on the DAC board and attenuate the 60MHz (approx.) switching spikes that the DAC generates.

In addition, since these are passive filters, they are effective at filtering any high-frequency noise which the active filter stages may allow through.

The third-order active LPFs only require a single op amp each (IC1 to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This view shows the fully assembled PC board. Be careful with the orientation of the ICs.

IC4). However, unlike the DAC board, there is no performance advantage to be gained by using OPA134 op amps over NE5534s. Instead, testing has revealed that it is the I/V converter stages on the DAC board that benefit from the improved performance of the OPA134s.

By contrast, on the Balanced Output Board, the op amps only act as unity-gain voltage buffers, and the NE5534 performs admirably in this role. However, you can use OPA134s if you wish. For example, if you are not going to be installing the unbalanced outputs, you will have two spare OPA134s from the DAC board, so you only need to buy two more for the Balanced Output Board.

Note that the board has pads for the 22pF compensation capacitors required for the NE5534s, and if you are purchasing op amps specifically for this board, NE5534s are recommended. Alternatively, if you decide to use OPA134s, you can leave out the 22pF capacitors (although installing them does not hurt).

Outputs

The output of each op amp appears at pin 6. IC1 and IC2 provide the differential output signals for the left channel and these respectively drive pin 2 and pin 3 of the left-channel XLR socket (CON1), via the low-pass passive filter stages. Similarly, IC3 and IC4 drive the right-channel XLR socket (CON2).

The XLR output connectors are mounted directly on the PC board, while the input signals from the DAC board are fed in via 3-way screw terminal blocks. The latter provide a 0V connection for shielding purposes, but the shield should only be connected at *one* end.

Power for the Balanced Output Board circuitry is derived directly from the ±15V outputs of the Power Supply Board. The supply rails are fed in via another 3-way screw terminal block on the Balanced Output Board, with two 100µF capacitors providing additional filtering.

Construction

Refer now to Fig.2 for the component layout for the Balanced Output PC board. This board is available from the *EPE PCB Service*, code 833. As can be seen, the assembly is reasonably straightforward.

Begin construction by checking the PC board for defects, then start the assembly by installing the resistors and wire links. You can either use 0.71mm tinned copper wire for the links, or you can use 0Ω resistors (as in the prototype).

Next, install the IC sockets, ensuring they are correctly oriented. Follow these with the terminal blocks, ensuring that the openings point towards the edge of the board in all cases. Be sure to seat them properly on the PC board before soldering their pins.

The capacitors can go in next. The two 100µF filter capacitors are polarised, so watch their orientation. Follow them with the XLR connectors, then install the four ICs (again, make sure they are correctly oriented).

Finally, complete the board assembly by fitting M3 × 6mm tapped nylon spacers to the mounting points. You will need at least four of these (one in each corner) and they should be secured using M3 × 4mm screws.

It's also a good idea to fit an extra spacer between the two XLR sockets, to ensure extra rigidity when plugging in external leads. An extra mounting point is also provided along the opposite edge of the board, but its use is optional.

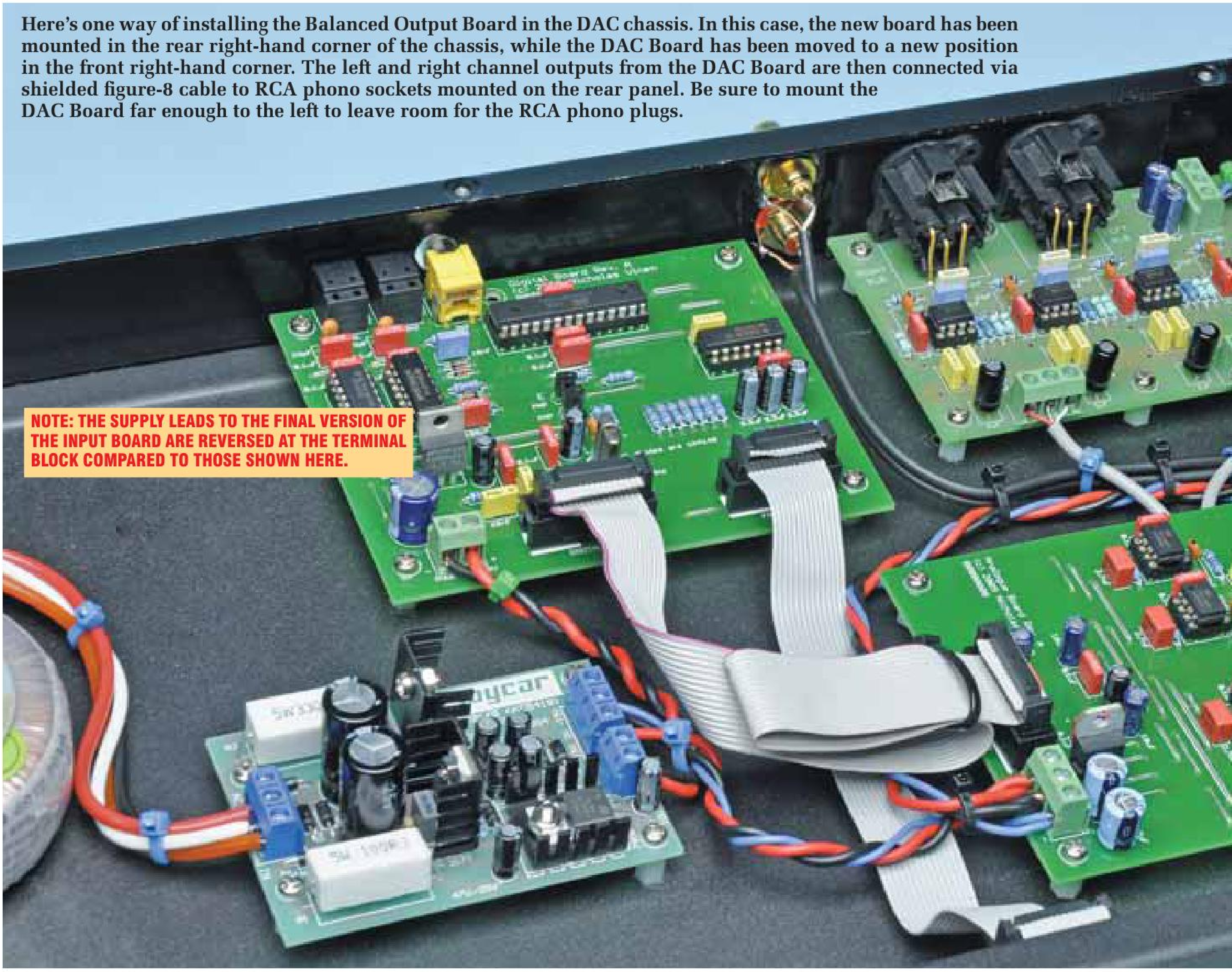
Installation

There are a couple of options when it comes to installing the Balanced Output Board into a case.

First, if you are starting from scratch and drilling your own case, then the board can be mounted with its XLR connectors protruding through the front panel, on the right-hand side. This would mean moving the Switch Board further towards the centre of the front panel than in the prototype, to allow room for the Balanced Output Board.

Table 2: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	4	100kΩ	brown black yellow brown	brown black black orange brown
❏	4	910Ω	white brown brown brown	white brown black black brown
❏	4	820Ω	grey red brown brown	grey red black black brown
❏	4	560Ω	green blue brown brown	green blue black black brown
❏	4	100Ω	brown black brown brown	brown black black black brown



Here's one way of installing the Balanced Output Board in the DAC chassis. In this case, the new board has been mounted in the rear right-hand corner of the chassis, while the DAC Board has been moved to a new position in the front right-hand corner. The left and right channel outputs from the DAC Board are then connected via shielded figure-8 cable to RCA phono sockets mounted on the rear panel. Be sure to mount the DAC Board far enough to the left to leave room for the RCA phono plugs.

NOTE: THE SUPPLY LEADS TO THE FINAL VERSION OF THE INPUT BOARD ARE REVERSED AT THE TERMINAL BLOCK COMPARED TO THOSE SHOWN HERE.

Alternatively, if you are installing the new board into a kit chassis, it will have to be mounted in the rear right-hand corner of the chassis, in place of the DAC board – see photo. The DAC board is moved to the location shown in the photo and installed with its RCA phono output connectors facing towards the right-hand side panel. The phono outputs are then connected via figure-8 shielded cable to a pair of phono sockets mounted on the rear panel between the Input Board and the Balanced Output Board.

Whichever method you choose, you will have to drill the necessary mounting holes for the boards and cut holes in the front or rear panel to match the XLR sockets.

The XLR socket holes are the first on the list. These are holes best made by initially drilling two pilot holes 35.5mm apart at the correct height. They are then reamed out to 22mm to allow the socket centre sections to protrude through.

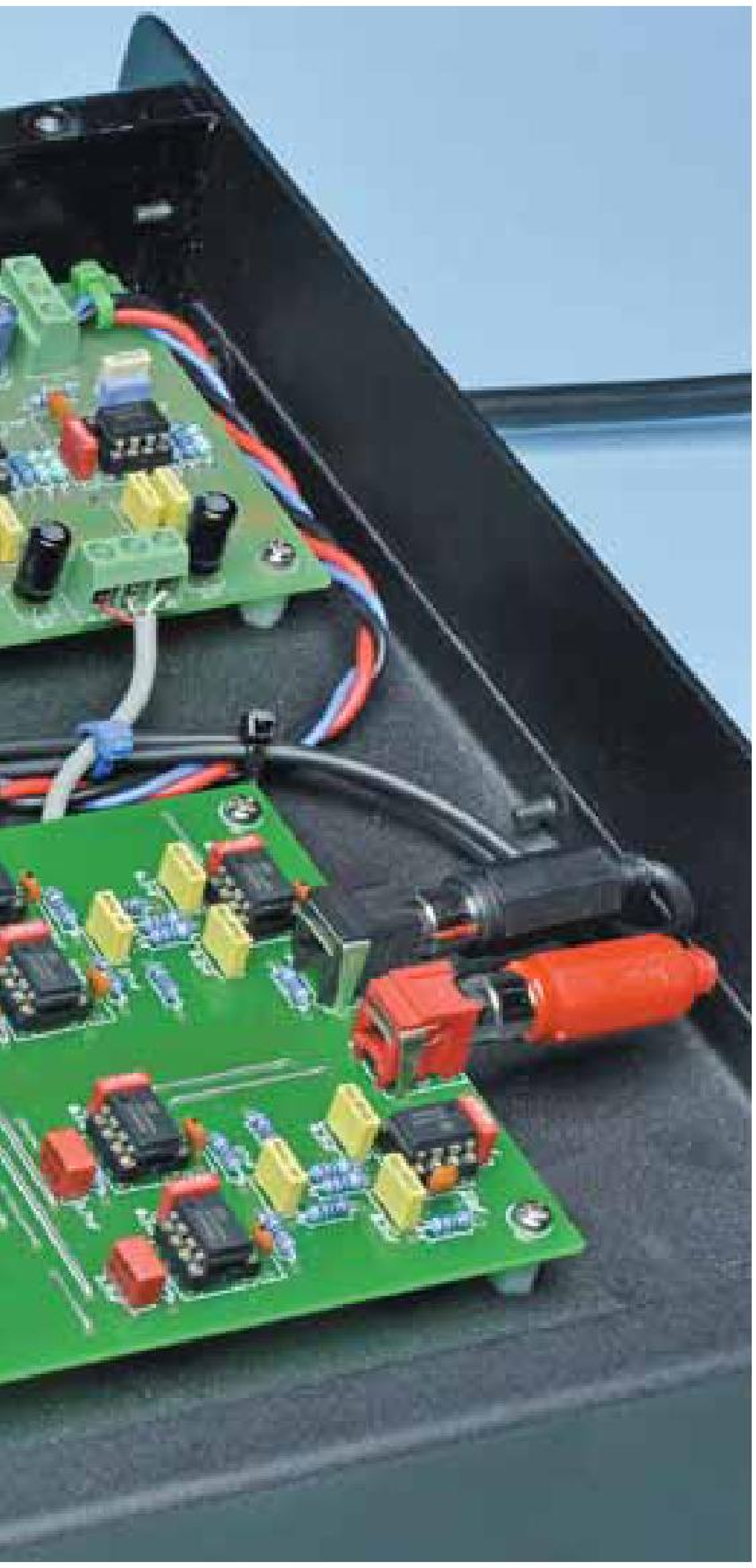
That done, mark out and drill the four 2.5mm holes around the outside edge of each cutout. The XLR connectors can then be firmly secured to the panel using the supplied self-tapping screws.

Having secured the assembly in this manner, the next step is to remove the nylon spacers so that you can mark out the mounting holes for the Balanced Output Board in the base of the chassis. The PC board is then removed so that the holes can be drilled (to 3mm).

Once these holes have been drilled, mark out and drill the two holes for the panel-mount RCA phono sockets. Again, use a pilot drill to start the holes, then carefully ream them to size (9.5mm) using a tapered reamer.

If you are modifying a kit chassis, then the DAC Board can be installed in the location shown in the photo. Once again, you will have to mark out and drill a new set of mounting holes. Note that the edge of the board should be at least 55mm from the right-hand chassis panel, to ensure sufficient clearance for the phono plugs.

Next, deburr all the mounting holes using an oversize drill before installing the boards in the chassis. Don't forget to refit the four screws through the panel to hold the XLR connectors in place. This step is vital because they are subject to quite a bit of force during cable insertion and removal.



Wiring

It's now just a matter of completing the wiring, as shown in Fig.2, Fig.3 and the photographs.

First, you will need to run three power supply leads (+15V, 0V, –15V) to the Balanced Output Board. These supply rails are derived from the output terminal block on the DAC Power Supply Board.

Unfortunately, it can be difficult to fit two wires into the terminal block entries (due to the leads already running to the DAC board), but there is a way around this – splice the wires into a 'Y' shape with heatshrink insulation applied to the join. You can then connect one end to the power supply, the middle to the DAC board and the remaining end to the Balanced Output Board. Make sure you don't get any of these +15V, 0V, –15V connections mixed up.

It's a good idea to twist the supply leads together, as shown in the photo. This not only minimises noise pick-up but also ensures that a lead cannot wander if it comes adrift. You should also use cable ties to additionally secure the supply leads at the terminal blocks.

Shielded cable

The connections between the DAC Board and the rear-panel RCA phono sockets are run using figure-8 shielded cable (ie, two cores with *separate* shields – do not use 2-core cable with a common shield for these connections). As shown, the leads are directly soldered to the rear-panel phono sockets at one end and are terminated in RCA plugs at the DAC Board end.

Alternatively, if you don't intend ever using the unbalanced outputs, then this wiring can be left out.

Two lengths of twin-core shielded cable are used for the signal connections between the DAC Board and the Balanced Output Board. Begin by stripping back 20mm of the outer insulation from one end of each cable, and about 40mm from each of the other ends. Then, at the 40mm ends, trim the shield/braid wires back completely so that they do not project out of the outer insulation.

Now, at the 20mm end of each cable, twist the shield wires together tightly and tin them with solder. That done, remove 10mm of insulation from the inner wires at both ends, then double the exposed wires back and tin them.

Finally, trim the shield wires back to about 10mm and attach the signal cables to the input terminal blocks on the Balanced Output Board – see Fig.2. As shown, the shield wire goes to the centre terminal of each block, the red wire to the '+' terminal and the white wire to the '–' terminal.

The red and white wires at the other end of each cable are connected to the pin 6 outputs of ICs 7, 8, 10 and 11 on the DAC Board. The best place to make these connections is at the 220Ω resistors that connect to these pins, as shown in Fig.3.

You can either make the connections to the top of the DAC Board or you can solder the wires to the pads on the underside of the board (as in the prototype). If you are attaching the wires to the top of the board, simply melt a little solder onto the exposed resistor legs, then solder each wire in turn.

Alternatively, if you are not installing the unbalanced outputs, you can leave out the 220Ω resistors and simply feed the wires down through the board holes before soldering them to the pads. **Either way, you must protect the board so that the trimmed shield wires can't short against anything.** That can be done either by using heatshrink sleeving or a blob of hot melt glue, or even insulating tape.

Parts List

1 PC board, code 833, available from the *EPE PCB Service*, size 110mm × 67mm
2 PC-mount male 3-pin XLR connectors plus self-tapping screws
3 3-way screw terminal block (5.08mm pitch)
4 8-pin machined IC socket
6 10mm tapped nylon spacers
6 M3 × 6mm machine screws
1 500mm length twin-core shielded cable

Semiconductors

4 NE5534 op amps (IC1 to IC4)

Capacitors

2 100µF 25V electrolytic
4 1µF bipolar electrolytic
4 100nF MKT
4 10nF MKT
4 5.6nF MKT
4 2.2nF MKT
4 1nF MKT
4 22pF ceramic

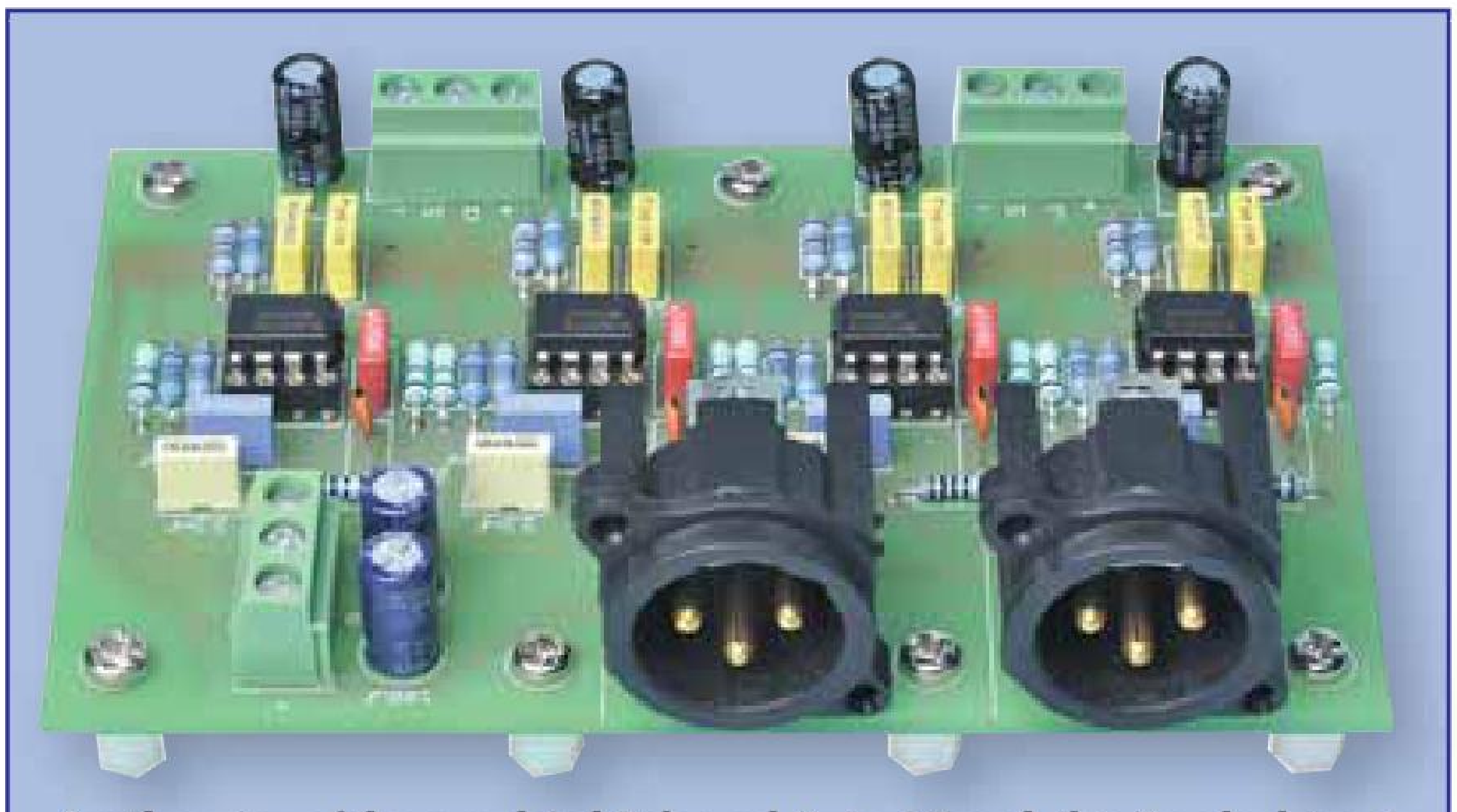
Resistors

4 100kΩ
4 910Ω
4 820Ω
4 560Ω
4 100Ω
4 0Ω or wire links

Miscellaneous

The following parts are necessary to complete the chassis wiring:

2 RCA plugs, 1 red, 1 black
2 panel-mount RCA sockets
1 500mm length figure-8 shielded cable
8 cable ties
1 600mm-length heavy-duty red hook-up wire
1 600mm-length heavy-duty blue hook-up wire
1 600mm-length heavy-duty black hook-up wire



Another view of the completed Balanced Output Board, this time looking at the XLR connectors. The latter are secured to the rear panel using the self-tapping screws supplied. This ensures that the solder joints on the board don't crack due to stress as cables are plugged in and removed.

Once all the wiring has been completed, secure it in place using cable ties, as shown in the chassis photo. This not only helps prevent leads from flexing and coming adrift, but also ensures that a wire cannot move and contact other parts of the circuit (including the mains terminals on the back of the IEC socket) if its connection is broken.

Don't get the channels mixed

Be sure to connect the leads exactly as shown in Fig.2 and Fig.3, so as not to transpose the left and right channels.

In particular, note that the components on the right-hand side of the DAC Board are actually for the left channel, ie, they drive the left audio output socket. Similarly, the parts on the left-hand side of the board drive the right channel audio output socket. This was done to simplify the layout of the PC tracks running from the DAC chip (IC6).

All you have to do is run the signal leads as shown in Fig.2 and Fig.3, and all will be correct. **There's just one wrinkle here – if you mount the Balanced Output Board on the front panel, then you should swap the signal leads running to the 3-terminal input blocks.** That way, the left-hand XLR socket (when looking at the front panel) will really be the left channel, while the right-hand socket will be the right channel.

Testing

Once the power supply and signal wiring are complete, power the Stereo DAC up and check that the +15V and –15V inputs to the Balanced Output Board are correct. If these are OK, you are then ready to connect the balanced outputs to your external equipment and check that they are functioning correctly.

If there is a problem, switch off immediately and use a multimeter to confirm that all power and signal connections are correct. If that checks out but it still doesn't work properly, you will need to remove the Balanced Output Board and check it for short circuits, missed solder joints and incorrect parts placement.

If you have not tested the rest of the DAC yet, then it's a good idea to temporarily disconnect the Balanced Output Board while you make the necessary checks. That way, you'll at least know that the rest of the DAC works correctly before looking for problems on the Balanced Output Board.

That's it – once wired up, the balanced outputs should provide a very clean output signal from the DAC, even with long cable runs.

Phantom power

Finally, note that phantom power should not be applied to the XLR sockets on the Balanced Output Board (ie, phantom power should be switched off). Alternatively, cut the tracks between the 100Ω resistors and the XLR sockets and install 10µF bipolar (BP) electrolytic capacitors across the gaps (ie, in series with the pin 2 and pin 3 outputs). *EPE*

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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

THERE SEEMS to be an endless stream of television programmmes along the lines of *100 Best TV Laughs*, *50 Greatest TV Cups of Tea*, and so on. If it has not already been aired, no doubt in due course there will be a programme called something like *100 Best TV clichés*!

Anyway, rather than being about a particular aspect of electronic project construction, this month's article will consist of some of the most useful pieces of advice for beginners. In fact, it is a sort of *EPE's Greatest Project Tips*.

The right one

Probably the best piece of advice is to choose a suitable project for your first attempt at construction. If you choose something totally inappropriate you will find it tough going, even if you get everything else right. There is a temptation to start with a 'mega-project' that will impress your family and friends.

However, the chances of making a mistake with a large project are much greater than when building something more modest. It is something where the square rule seems to apply: 'If one project has ten times as many components as another, the chances of problems occurring are probably about one hundred times greater when building the more complex project'.

Technical expertise is very helpful, but it is not necessary to understand how a project works in order to build it properly. On the other hand, you do need to have a proper understanding of what it is supposed to do and how to use it. Otherwise you could spend hours trying to get a supposedly faulty project to work, when it has actually worked perfectly all the time. You might even end up damaging a project that was working perfectly before you started fixing it!

The usual advice is to start with something fairly simple and straightforward like a household gadget. This is less exciting than a complex piece of scientific or audio equipment, but it represents a more appropriate and sensible starting point.

Main point

Beginners should certainly start with projects that are *battery* powered, and should definitely avoid any projects that are mains powered or which control a piece of mains-powered equipment. With a battery-powered project it is possible that one or two of the components will be damaged if you get things seriously wrong, but you should be perfectly safe. In most cases, the components will all live to fight another day.

There should be no significant danger in building a project that is powered from the mains via a ready-made adapter. Provided it has the usual *safety compliance markings,* the adapter should be safe to use. It should provide complete isolation from the mains supply in addition to having any necessary fuses or safety cut-outs.

When dealing with the mains electricity supply you have to treat it as potentially lethal, because that is precisely what it is. Any projects that connect to the mains supply are also potentially lethal. Projects that are powered from the mains or have any direct connection to it must only be tackled by those with a suitable amount of experience at project construction. Even if a project uses only half a dozen components, if it connects to the mains supply it is ***not*** suitable for beginners.

Now you see it

Before starting to buy the components for any project that is more than a few months old, it is essential to check that all the components are still available. There is otherwise a risk of purchasing most of the parts only to discover that some of the remaining components are no longer available. Unfortunately, just one crucial part becoming unobtainable is sufficient to prevent the project from being completed.

The problem of components disappearing from the market is one that tends to be associated with semiconductors in general and integrated circuits in particular. However, any specialised component can be suddenly withdrawn from the market.

Product rationalisation has resulted in many popular components of the past going out of production and becoming unavailable soon afterwards. It is not just 'golden oldie' components that are troublesome though, and recently introduced components that fail to 'make the grade' invariably disappear soon after they were introduced.

Consequently, it is not only old projects from years ago that suffer from component supply difficulties. It can occasionally happen with recently published designs, and it is always a good idea to check the availability of any out-of-the-ordinary components before starting to order the other parts.

In the know

It is important to obtain as many catalogues and price lists as you can, and (or) bookmark some online catalogues in your browser and then study them. Most electronic component suppliers now have excellent online catalogues at their websites. These tend to be updated more frequently than their printed counterparts, and are, therefore, a more reliable guide to product availability.

Having access to several catalogues maximises your chances of tracking down any unusual components, and also enables you to compare prices from several suppliers, so that the best deal can be chosen. The project article should suggest at least one source for any specialised components that are not available from the usual sources.

It is worth looking through component catalogues to familiarise yourself with the different types of component that are available. This can make life much easier and save a lot of time when you start buying components for a project. Many component catalogues contain useful data and information about the listed components. Online catalogues often have links to the manufacturer's data.

Tools for the job

Make sure that you have the right tools for the job before starting your first project. It will not usually be necessary to start from scratch when buying the tools needed for electronic project construction. Many of the tools required are the type of thing that will already be present in the average household toolbox. Tools such as hacksaws, drill bits in a range of sizes, files, pliers, adjustable spanners, and screwdrivers are needed when undertaking the mechanical aspects of project construction.

Unfortunately, most do-it-yourself tasks are on a much larger scale than your average electronic project. The tiny size of many modern components means that project construction has more in common with watch or clock making than fitting shelves on a wall or assembling flat-pack furniture. Some existing tools, such as screwdrivers and drill bits might have to be augmented with smaller versions that are more appropriate to most electronic project building.

Stripped for action

It is essential to have proper wire cutters and strippers, which can be in the form of separate tools, or a single type that combines both functions. An inexpensive wire stripper and cutter tool is all you need initially – see Fig.1. Avoid improvising using knives and scissors, as this type of thing rapidly ruins the tools and provides inadequate results.

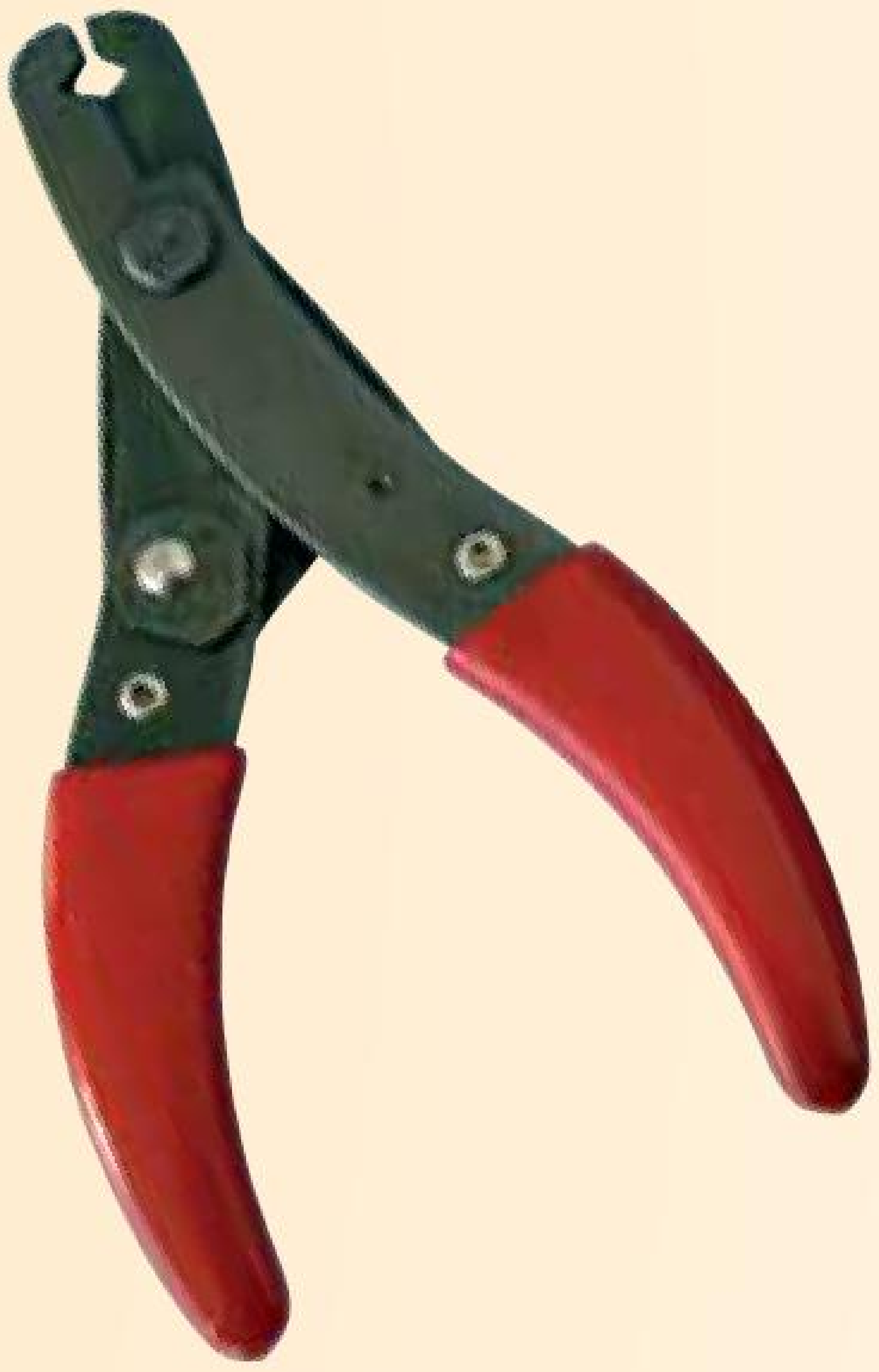


Fig.1. A combined tool such as this is all you need for cutting wires and stripping plastic insulation from them. Improvising using implements such as scissors and penknives will give low quality results and is a bit dangerous

Stripped wires tend to break unless the correct type of tool is used. Improvising using any inappropriate cutting tool is inevitably going to be at least a little dangerous.

Gift wrapped

Semiconductors are usually supplied in fancy packing of some kind, but the packing is not 'just for show'. A substantial percentage of modern semiconductors are easily damaged by high static voltages that are common in modern environments.

The fancy packaging is designed to keep static charges at bay. Leave semiconductors in their packaging until it is time to fit them on the circuit board. As far as possible, avoid touching the leads or pins, and work well away from any likely sources of static electricity.

There are various pieces of equipment available that help to protect vulnerable semiconductors while you are handling them. These are probably not worth the expense when dealing with devices that cost a few pence, but it is worth investing in an antistatic wristband and a work mat if you start using more expensive semiconductors.

Soldering on

To some extent you will learn the necessary skills while building projects, but it is definitely a good idea to become reasonably proficient at soldering before you start your first project. Otherwise, you could end up writing off your first project to experience.

A good quality electric soldering iron with a miniature bit of about 2mm diameter is an essential item, and one with a rating of about 15W to 20W is ideal. Obtain a matching stand rather than trying to improvise something than might not be entirely effective or safe.

Mistakes are made from time to time, and a desoldering tool is almost as important as a soldering iron. One of the spring-loaded pump types should do the job well at minimum cost.

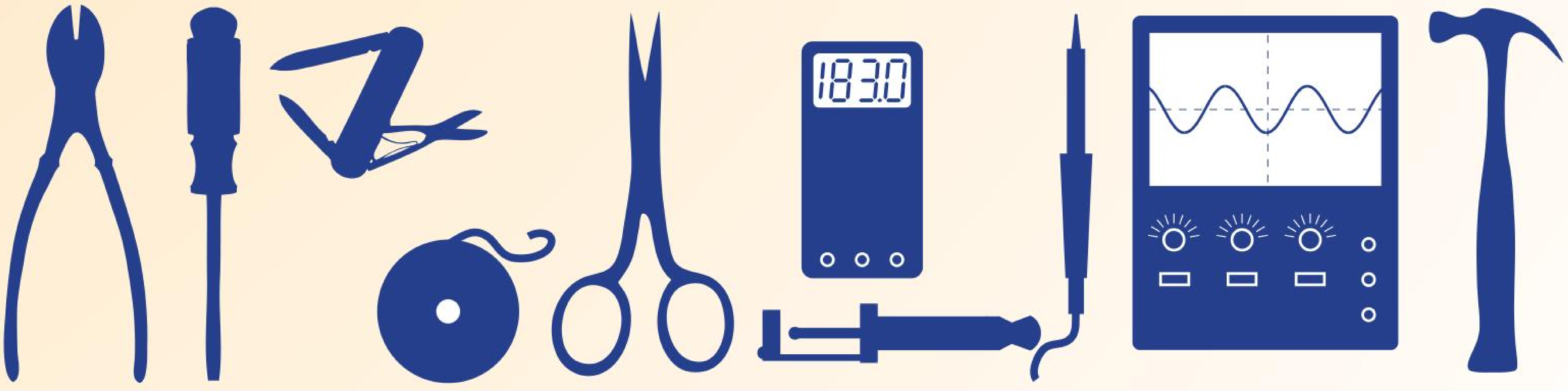
Buy a small piece of stripboard and a few resistors or other cheap components, and practice soldering until you become reasonably proficient. Alan Winstanley's excellent soldering guide at **www.epemag.wimborne.co.uk/solderfaq.htm** provides all the soldering advice you will need.

Most electronic components can be damaged by heat, so you need the ability to produce good soldered joints quite quickly. You are taking too long if components change colour, start smoking, or show other signs of damage.

Think small

Having spent a huge number of hours building tiny electronic gadgets, and repairing cameras and lenses, I find it difficult to adjust to tasks that are on a much larger scale. Similarly, if you are used to servicing cars and knocking holes in walls, adjusting your mind to the minute world of electronics could be a bit tricky at first.

Always proceed carefully using a minimum amount of force or you will soon have a collection of broken



components, fixings with stripped threads, and so on. Accuracy is very important when drilling holes or cutting things to size. A millimetre is a very long way in the world of electronics.

It is only natural to be in a hurry to get a project finished so that you can try it out, but the 'bull in a china shop' approach does not work well when undertaking electronics construction. The slow and careful approach is more likely to be successful, preferably checking and double-checking everything along the way. Try to be methodical about things and complete one task before moving on to another.

Up close

It is possible to save a great deal of hassle later on if a complete circuit board is thoroughly checked before it is installed in the case and wired to any off-board components. In addition to the usual checks that everything is in the right place and, where appropriate, fitted the right way around, it is a good idea to carefully inspect the underside of the board. There is usually a fair amount of contamination on the underside of a completed board, and this is mainly excess flux from the solder. It is much easier to see the board properly if this is cleaned away, which is easily achieved by some vigorous brushing with a toothbrush or something similar.

Due to modern miniaturisation, it is often difficult to see flaws on the underside of the board. Even if you have good eyesight at short distances, it is still a good idea to view the board via some form of magnifier. A good quality magnifying glass will help, but a loupe is better.

The type used by watchmakers and jewellers often have a rather narrow field of view, and the photographic variety – Fig.2 (below left) – is better for this application. An old camera lens having a focal length of about 50mm – Fig.2 (below right) does the job quite well if used at full aperture.

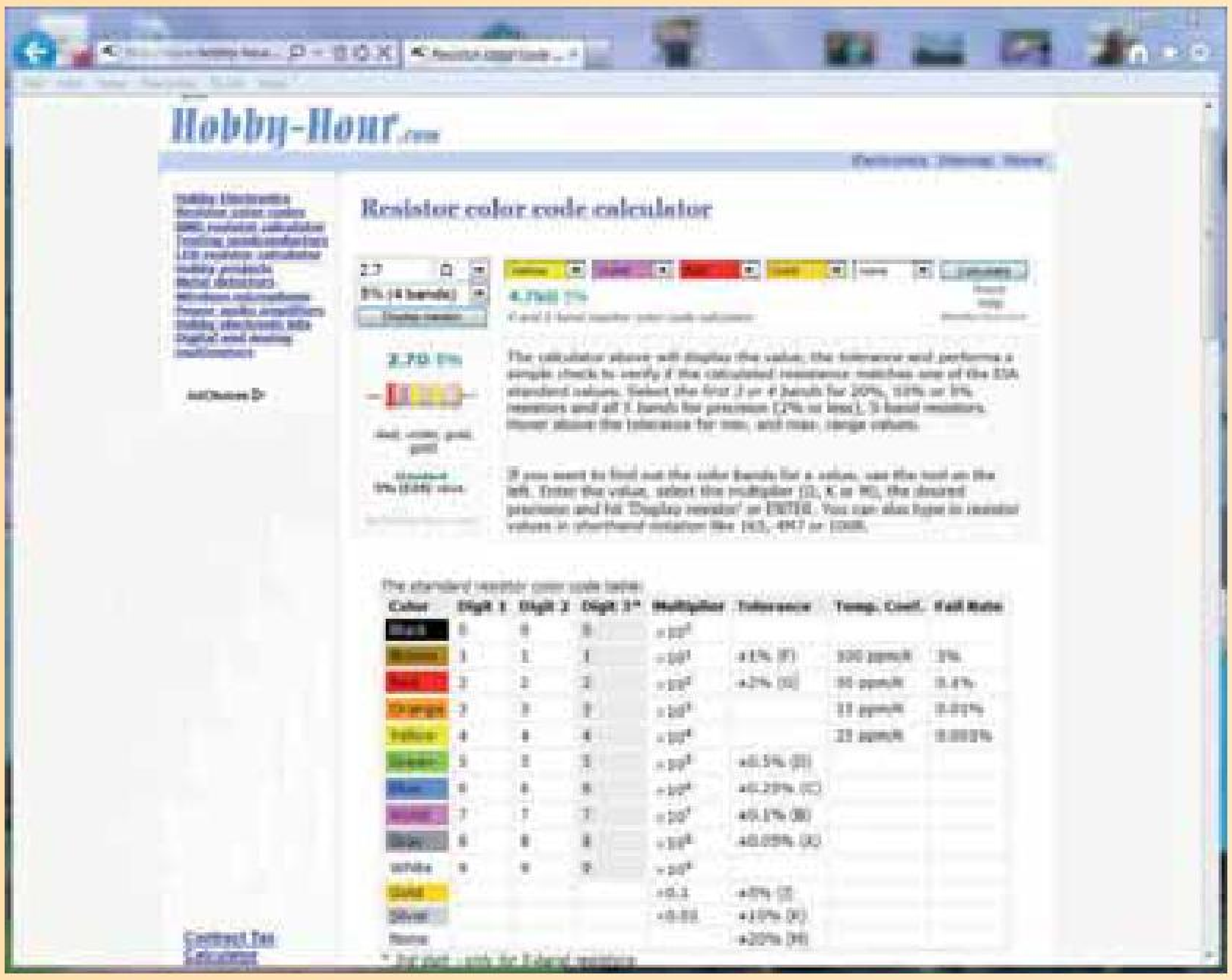


Fig.3. Anyone can check resistor values using one of the online resistor code calculators. The Internet is a very useful resource for the electronics enthusiast

There are two main types of fault to look for, which are bad soldered joints and short-circuits between copper tracks or pads due to tiny pieces of excess solder. It is probably best to regard any soldered joint as bad if it appears to be in any way out of the ordinary, such as having a rough surface or an odd shape. Use a desoldering tool to remove as much of the existing solder as possible and then redo the connection.

Short-circuits caused by excess solder can normally be cleared using the tip of a soldering iron. However, in some cases it will be necessary to remove all the solder in the vicinity using a desoldering tool, and then redo any connections that were affected.

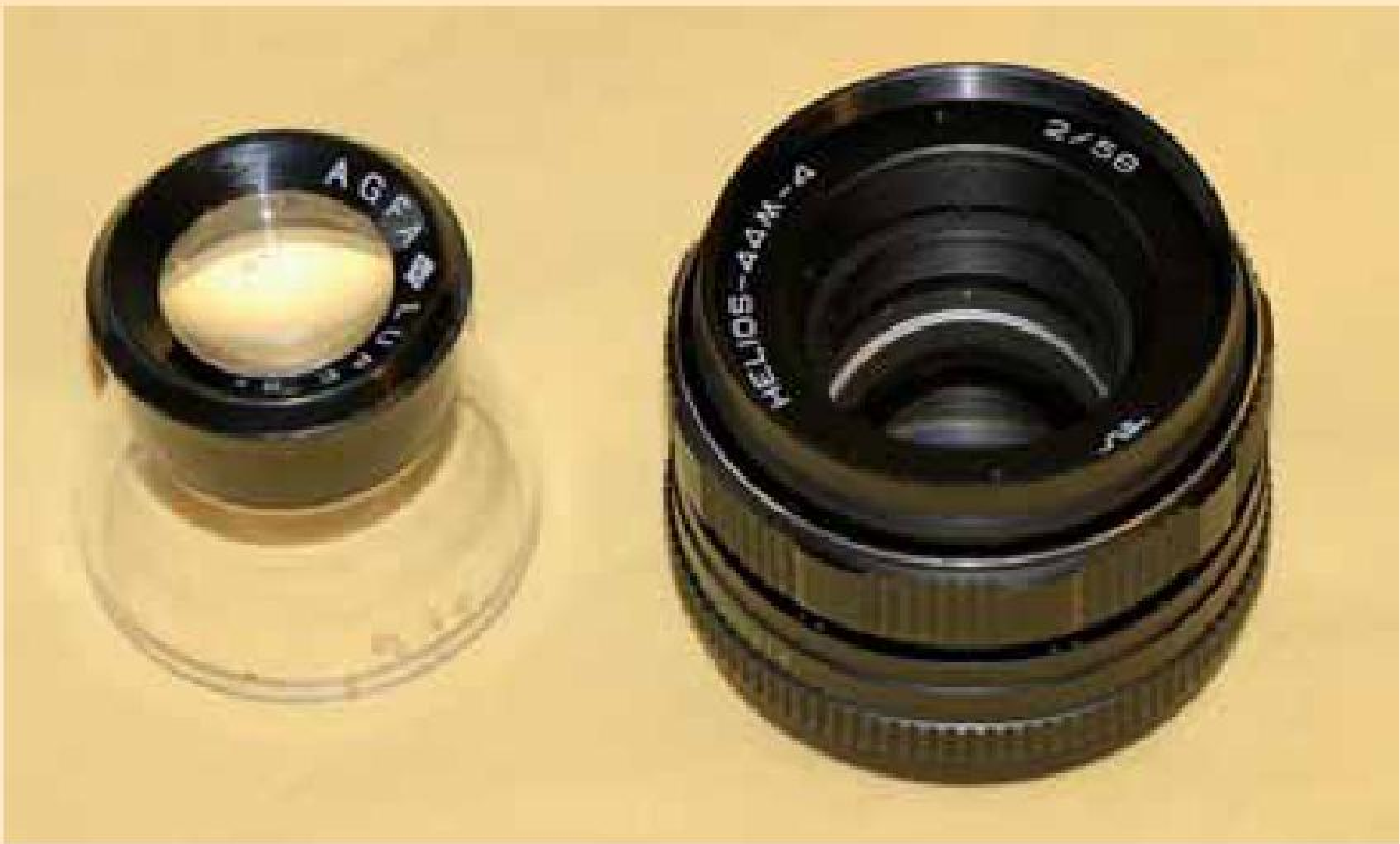


Fig.2. A photographic loupe (left) is idea for inspecting circuit boards. The standard lens from an old SLR camera (right) works quite well in this application if set at full aperture

Second pair of eyes

When a newly completed project fails to work, it is important to heed the advice of a well known television character; 'don't panic'. Switch off the unit immediately and check it all again very thoroughly. Unfortunately, having already fooled yourself into thinking that something is right when it is has actually been done incorrectly, it is likely that you will continue to do so.

When finding the problem proves to be impossible, despite checking the unit several times, it is best to put it to one side and try again the next day, or perhaps after two or three days. Looking at it afresh you are far more likely to notice any minor error that had previous gone unnoticed.

Taking this a step further, if at all possible, get someone else to check the unit for you. It does not require someone with any technical knowledge to check that the actual unit corresponds correctly with the printed circuit layout and wiring diagrams.

They can also check the values of components that are not colour coded. In fact, they can even check the values of colour coded resistors using one of the numerous online resistor code calculators, such as the one shown in Fig.3 (**http://www.hobby-hour.com/electronics/resistorcalculator.php**). There are many online resources such as this that have useful information and aids for beginners at electronics, including the *EPE* site of course (**http://www.epemag.net/**).

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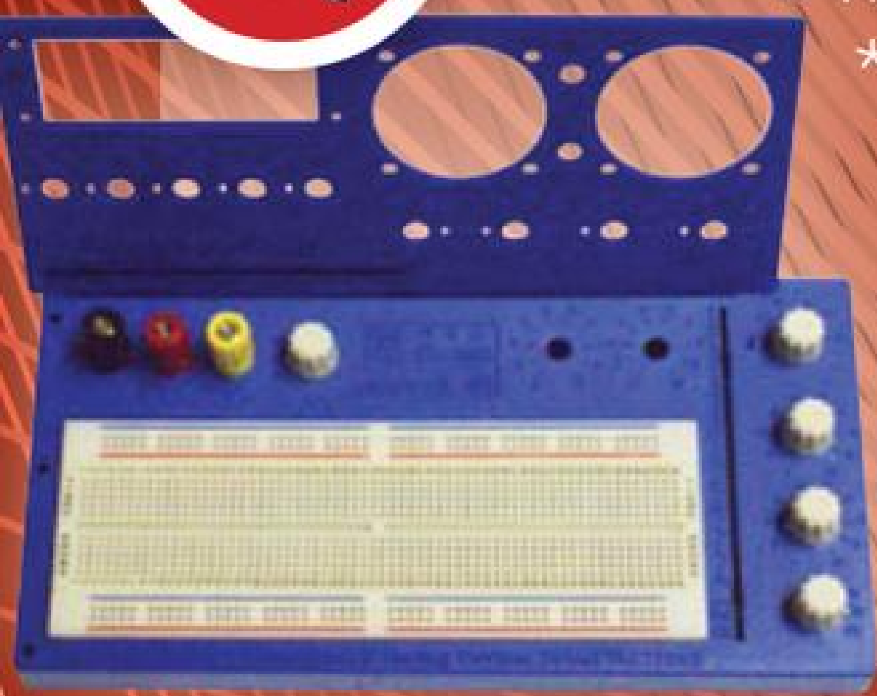

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CIRCUIT SURGERY

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BY IAN BELL

Digital waveform generation

FREQUENT *EPE Chat Zone* contributor ***Agustín Tomás*** posted the following question about a digital sinewave generation circuit that he is working on. He also posted an LTSpice simulation file, so that we can see his schematic and simulate the circuit exactly as he did.

Shift register driven by a 12x clock. The six outputs loaded with weighted resistors to produce a sine-like waveform. [see Fig.1]

Network output fed, via a unity gain buffer, to a six-pole LP Butterworth active filter, designed (FilterLab) for f_c*= 1150Hz.*

My intention is to use a sinewave between 10Hz and 1KHz.

After testing, I found that below 200Hz the output is bad, coming to almost copy the step-like input! Besides revising the design with FilterLab and the hardware, I simulated it, confirming the bad performance at the lower end. LT's .asc file is attached.

The board is already populated and the number of op amps (1 × TL074) thus fixed. Any chance to improve it? Otherwise, I will have to throw the stripboard away, which took me ages to assemble.

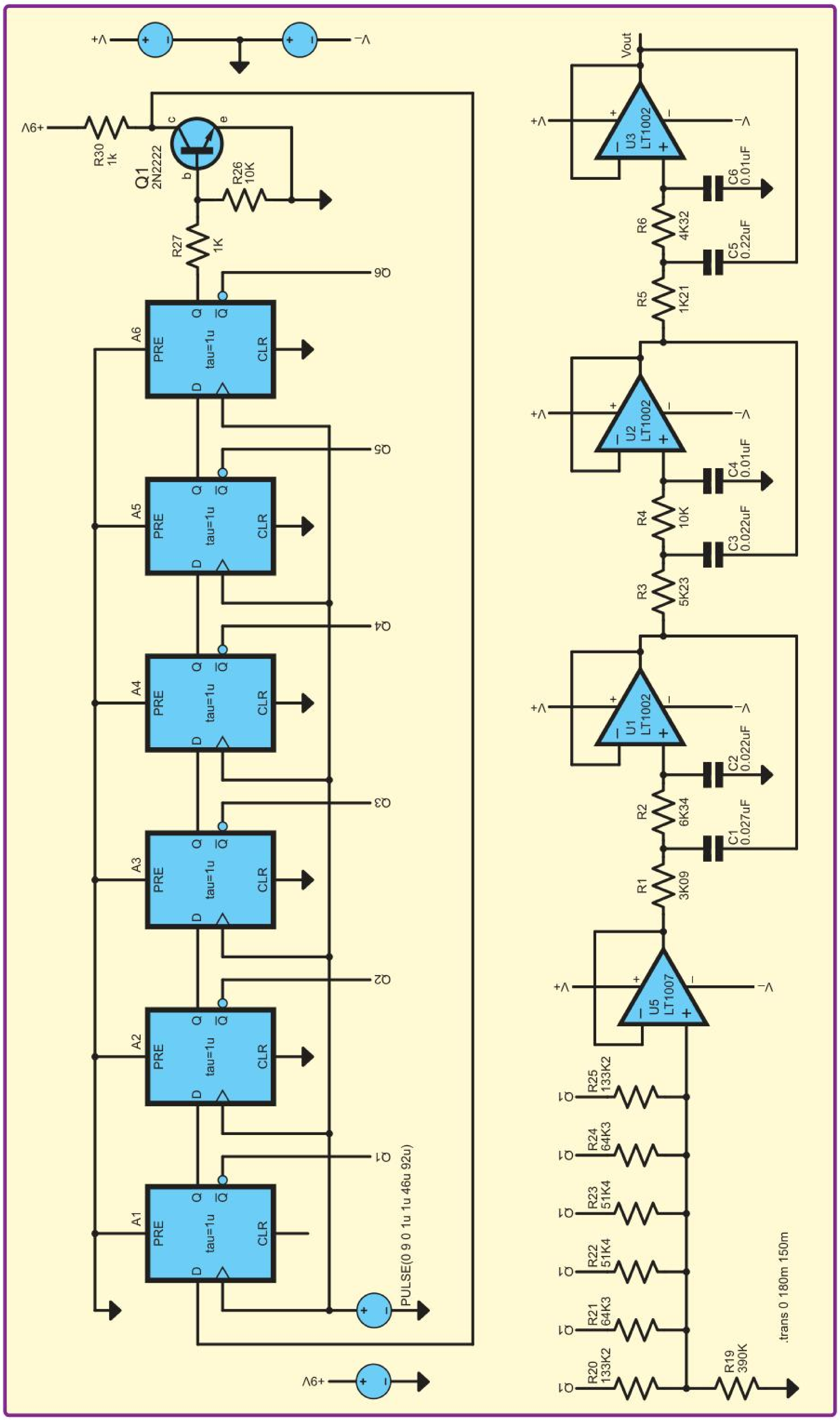
Digital waveform generation

Digital waveform generation is a useful and widely used technique in electronics, in applications such as test and measurement instruments, communications systems and sound synthesisers. For the benefit of readers who may not be familiar with what he is trying to do, we start by describing the operation of Agustín's circuit, and some aspects of how the simulation is set up.

We will then look at some theory of digital waveform generation, which explains the difficulties Agustín is having with filtering. As this is an interesting topic, worthy of further discussion, next month we will look at other approaches to creating waveforms digitally.

The schematic of Agustín's circuit is shown in Fig.1. Fig.2 shows the waveforms on the clock and flip-flop outputs (signals Q1 to Q6). The clock is produced by the V3 pulse source, and has a period of 92μs, which is a frequency of about 11kHz.

Fig.3 shows the clock, the output of the op amp U5 (raw digital sinewave at the filter input) and the output of the



+V
V–
+9V
R30
1k
Q1
2N2222
R26
10K
R27
1K
c
b
e
A1
A2
A3
A4
A5
A6
PRE
CLR
D
Q
$\overline{Q}$
tau=1u
Q1
Q2
Q3
Q4
Q5
Q6
PULSE(0 9 0 1u 1u 46u 92u)
R20
133K2
R21
64K3
R22
51K4
R23
51K4
R24
64K3
R25
133K2
R19
390K
.trans 0 180m 150m
U5
LT1007
R1
3K09
R2
6K34
C1
0.027uF
C2
0.022uF
U1
LT1002
R3
5K23
R4
10K
C3
0.022uF
C4
0.01uF
U2
LT1002
R5
1K21
R6
4K32
C5
0.22uF
C6
0.01uF
U3
LT1002
Vout

Fig.1. Agustín Tomás' digital sinewave generation circuit

filter (Vout, which is hopefully a good smooth sinewave). Fig.3 shows the sine output when the circuit is behaving well. The clock frequency is about 11kHz and the sine output is around 900Hz.

If we reduce the clock frequency tenfold and simulate for ten times as long, then we get results with very similar shaped waveforms at the filter input, but the output is a very poor sinewave (at about 90Hz) – Fig.4. A further tenfold reduction in clock frequency produces a final output that looks little different from the raw digital sinewave (Fig.5). This is exactly the problem Agustín describes in his posting.

Johnson ring counter

The flip-flops A1 through to A6 form a shift register. The output of the final stage is connected back to the serial input via an inverter. This causes the circuit to produce a repeated pattern on its outputs, as shown in Fig.2. This circuit is called a twisted ring counter or Johnson counter.

Fig.6 shows a simplified diagram of a 4-bit version of this circuit, in which the shift register is depicted as a SIPO block (serial in parallel out). If the circuit in Fig.6 is reset to 0000 at power on it gives the output sequence shown in Table 1 – it is perhaps clearer to see the patterns of 1s and 0s in this table than by looking at the waveforms.

In general, using *n* flip-flops in a Johnson counter gives us *2n* states before the pattern repeats. Agustín uses six flip-flops, so the digitised sine waveform has 12-steps per cycle, which is clearly seen in Fig.3. The Johnson counter switches on all its outputs one by one, and then switches then all off one by one. This produces a voltage which increases progressively and then decreases again, following the same steps in reverse. A sinewave starting at the negative peak conforms to this pattern.

LTSpice simulation

The D-Type flip-flops in the LTSpice simulation do not accurately represent real devices. The LTSpice logic devices are generic idealised 'special function' behavioural models. Unlike the op amps, they do not attempt to model specific real devices, such as the 4000 series CMOS logic.

The DFLOP (LTSpice flip-flop component) logic output defaults to 0V for logic zero and 1V for logic one, with a logic threshold of 0.5V. Default LTSpice gates and flip-flops all have no propagation delay and a 1Ω output impedance. It is possible to change these values using the component attribute editor (accessed by right-clicking the component symbol). Agustín has set the *RC* time constant of the flip-flop output to 1µs (the *tau* value on the schematic), which prevents unrealistic instantaneous voltage switching on their outputs.

The LTSpice flip-flop model accounts for the fact that the simulation waveforms for Q1 to Q6 are 1V square waves, whereas the flip-flop clock input is at 9V. The logic one voltage could be changed using the component attributes to make this more realistic; but as all the logic output voltages are equal and the clock voltage has no direct influence on the analogue output, this would not fundamentally change the circuit operation. The sinewave output amplitude would change to correspond with a different logic voltage.

The waveforms in Fig.2 indicate that Q1 starts at logic zero, with the other flip-flops at logic one. There does not seem to be any reason for this from

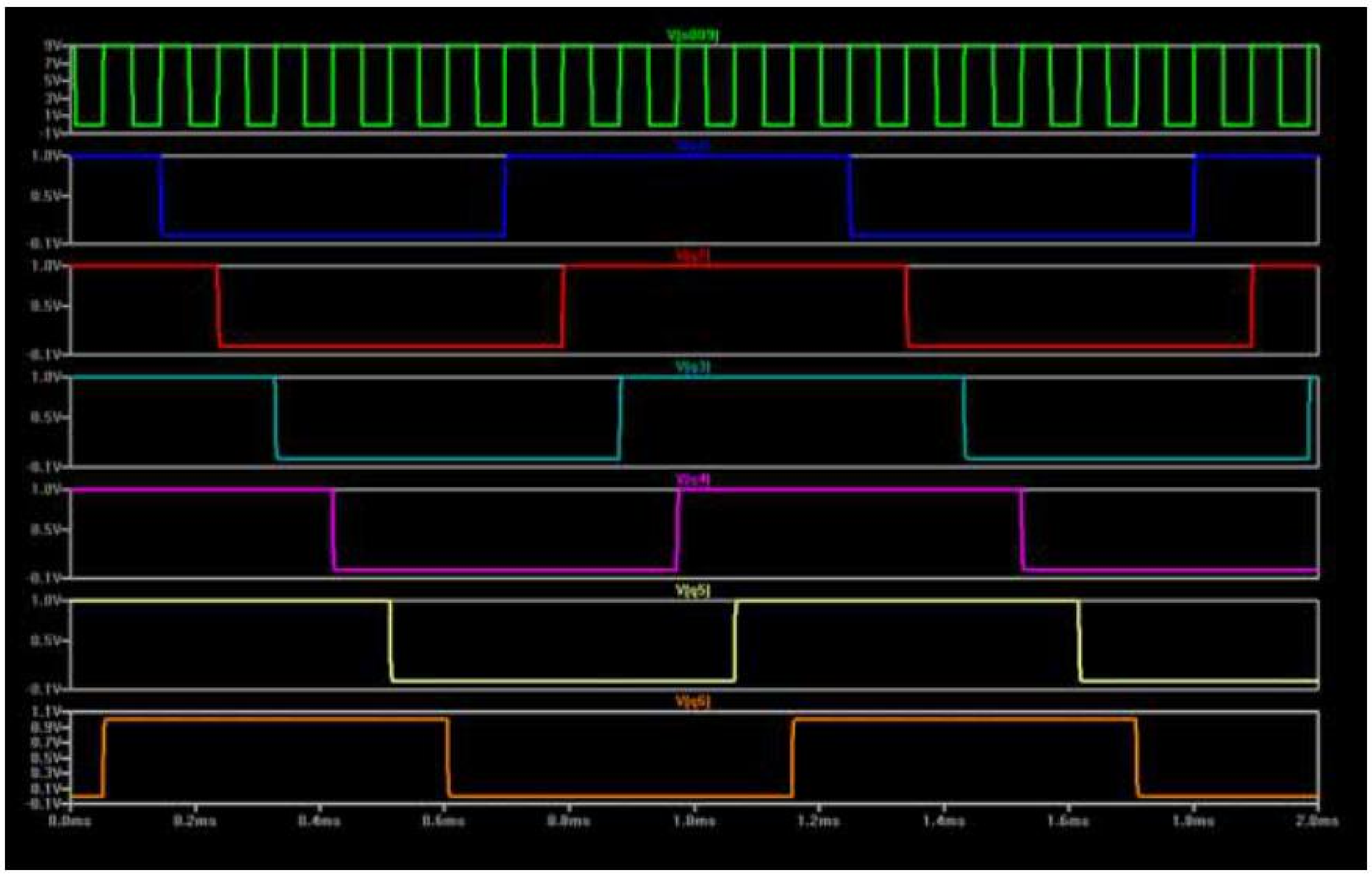


Fig.2. Digital waveforms from the Johnson counter used to control the sinewave generation

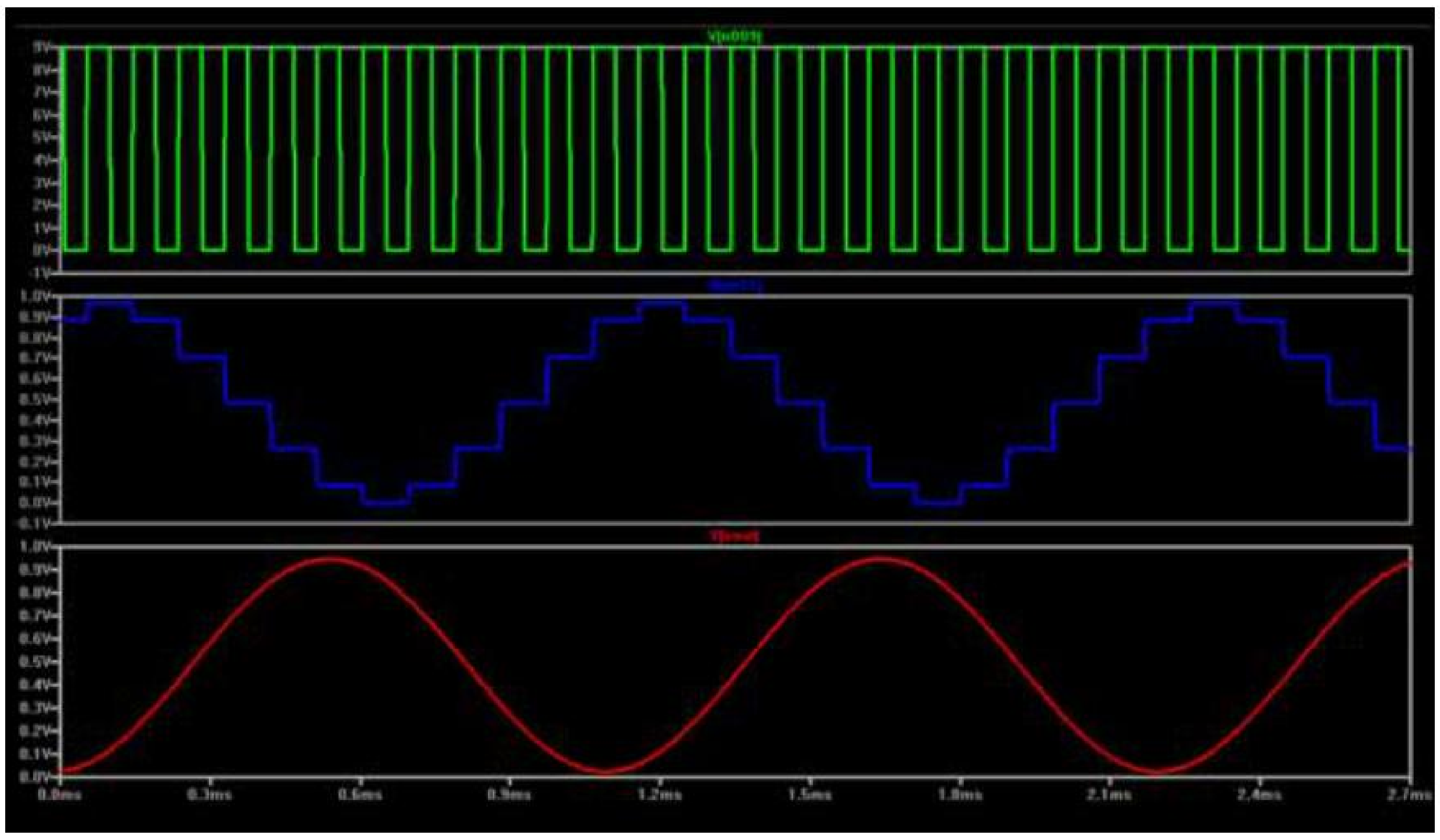


Fig.3. Sinewave output when the circuit is functioning well (900Hz)

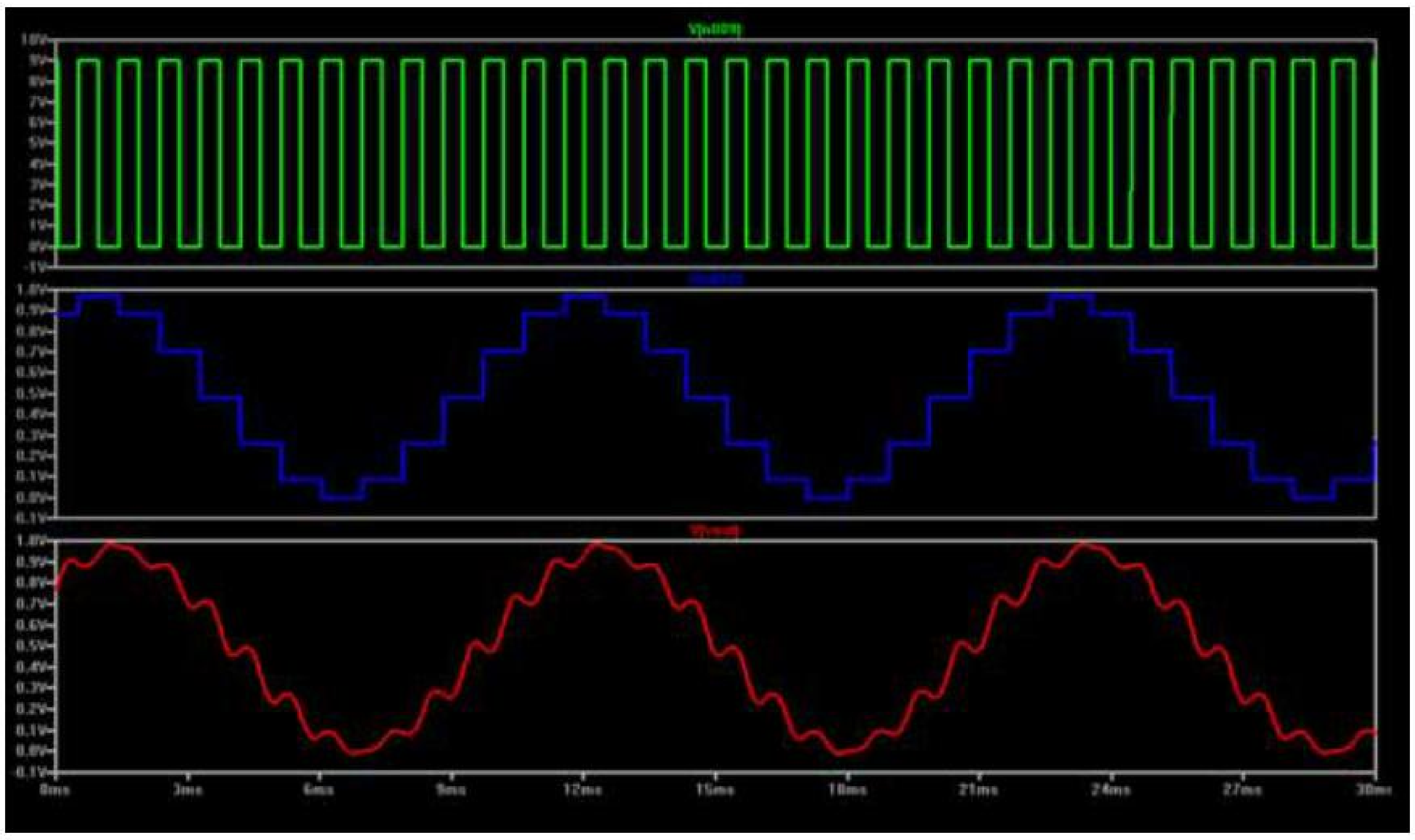


Fig.4. Sinewave produced by the circuit using a clock frequency ten-times lower than for Fig.3. The output is at about 90Hz and is clearly only partly smoothed

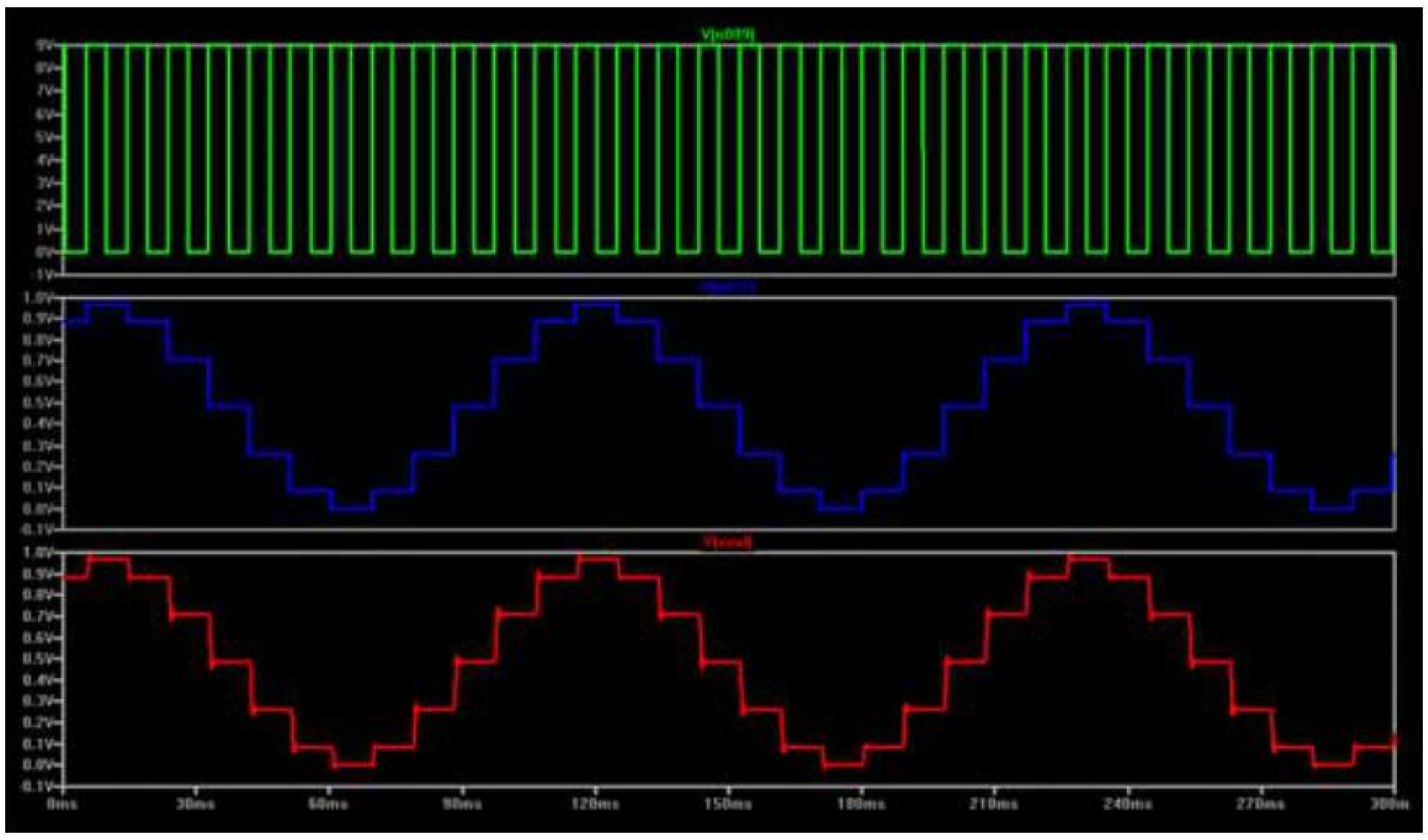


Fig.5. Sinewave produced by the circuit using a clock frequency 100-times lower than for Fig.3. The sine output is at about 9Hz. At this frequency, the filter has little effect

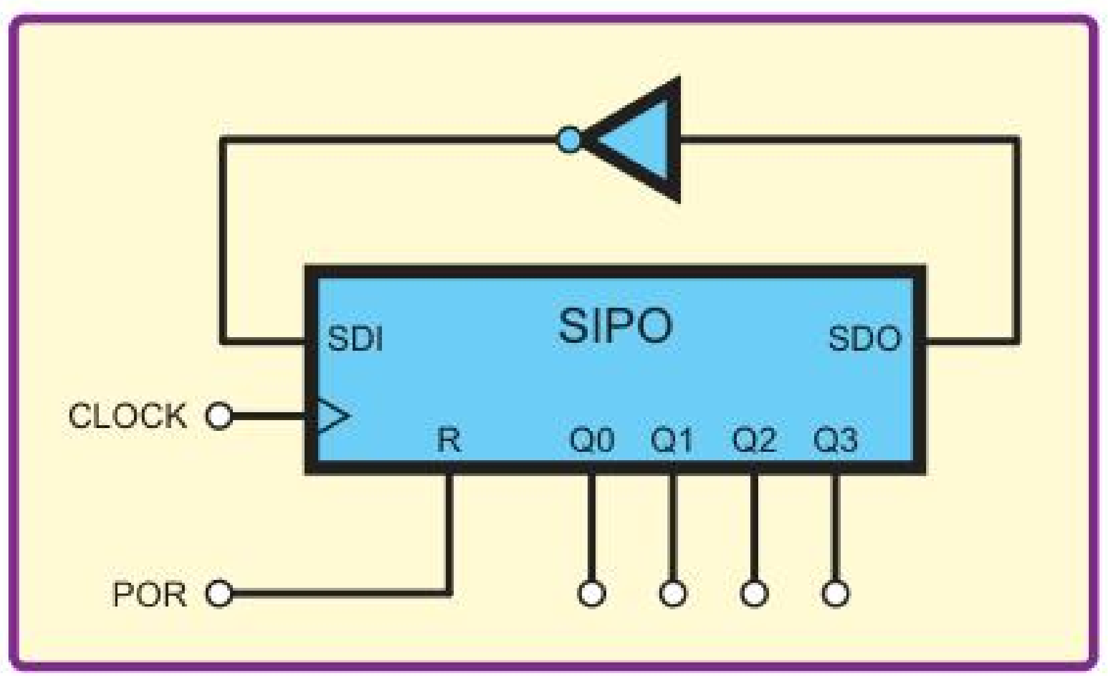


Fig.6. Simplified 4-bit Johnson ring counter schematic

Table 1: Output sequence from Fig.6

Q_0	Q_1	Q_2	Q_3
0	0	0	0
1	0	0	0
1	1	0	0
1	1	1	0
1	1	1	1
0	1	1	1
0	0	1	1
0	0	0	1
0	0	0	0
1	0	0	0

At each clock, the output pattern changes to the next line in the table. When it reaches the end it returns to the first pattern

the schematic, but a careful look at the simulation command

```
.tran 0 180m 150m
```

(a 180ms transient simulation) shows that the waveforms start being displayed after 150ms of simulation.

Looking at the waveforms from time zero indicates that the flip-flops all start at logic one, with Q1 going low immediately due to the first clock edge. We assume initialising to one is default behaviour for the LTSpice flip-flops, but the documentation in LTSpice's help is minimal.

In a real implementation of the circuit, a power-on reset would be required to ensure correct initialisation of the flip-flops. At power-up, the flip-flops must go into one of the valid states of the Johnson counter, with the specific state setting the start point of the sinusoidal waveform.

Digital-to-analogue converter

The outputs from the Johnson counter (Q1 to Q6) are fed to what is effectively a digital-to-analogue converter (DAC) formed by resistors R19 to R25 and the LT1007 op amp, U5. The op amp is in unity-gain configuration and buffers the voltage from the resistor network. The DAC in this circuit is not conventional; it designed to work with a limited range of input codes (those produced by the Johnson counter, rather than all 6-bit binary values) and produces the required output voltages for approximating a sinewave.

The resistors form a potential divider between ground (0V, also the logic zero voltage) and 1V (the logic one voltage). The effective ratio of upper to lower resistance (and hence the output voltage) depends on combination of logic levels; that is, which resistors have one end at 0V and which are at 1V. The potential divider is buffered by unity-gain op amp amplifier U5 to prevent it being loaded by the filter.

The filter is built using the three op amps U1, U2 and U3, and as Agustín states, is a sixth-order Butterworth low-pass circuit. The circuit uses three second-order, low-pass Sallen and Key filter stages. Filters like this are easily designed using software utilities such as Filterlab from Microchip (**www.microchip.com**) as mentioned by Agustín.

Frequency response

The simulated frequency response is shown in Fig.7. This was obtained by removing the rest of the circuit from a copy of the simulation schematic (keeping just the filter and its supply – V5 and V6), adding a voltage source to the filter's input and setting the small signal AC amplitude to 1mV.

Running an AC analysis with a decade sweep, 200 points per decade and start and stop frequencies of 100Hz and 500kHz respectively produces the results in Fig.7. To obtain the plot, the expression for gain (V[out]/V[in]) is added as a plot trace, rather than an individual voltage. For Fig.7, the phase plot was also removed by left clicking the axis on the right and selecting this option.

The AC analysis simulation shows that the cut-off frequency (–3dB point) is around 1.48kHz and the gain drops steadily until about 50kHz and then rises again. This higher frequency gain increase is an undesirable properly of Sallen and Key filters, which was discussed in *Circuit Surgery* in the recent November issue. This could cause reduction in the quality of the sinewave output, but is not the cause of the main problem with Agustín's circuit.

However, it is to the frequency domain that we have to turn to understand the problem with this circuit. The waveforms in Fig.3 to Fig.5 – the time domain view of the circuit – clearly show what is going wrong, but do not provide an explanation other than the filter is not doing an adequate job of smoothing out a stepped sinewave at lower frequencies.

Spectrum fundamentals

To better understand the circuit, we need to be aware of the set of frequencies present in our signals; that is their spectra. The only waveform for which the spectrum comprises just a single frequency is the sinewave (see Fig.8). Any other periodic waveform can be formed by adding together a set of sinewaves of various frequencies and

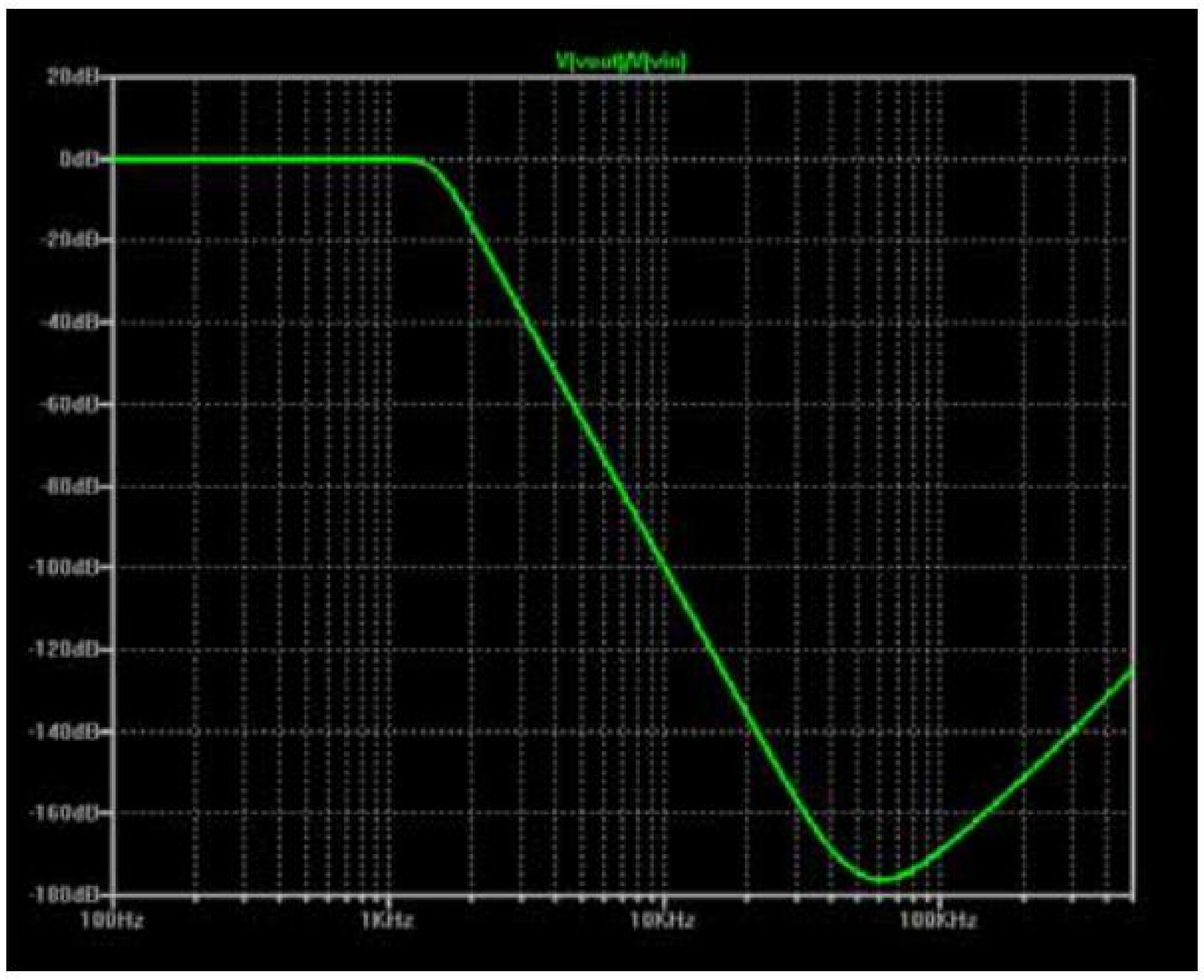


Fig.7. Filter frequency response of the filter from Fig.1

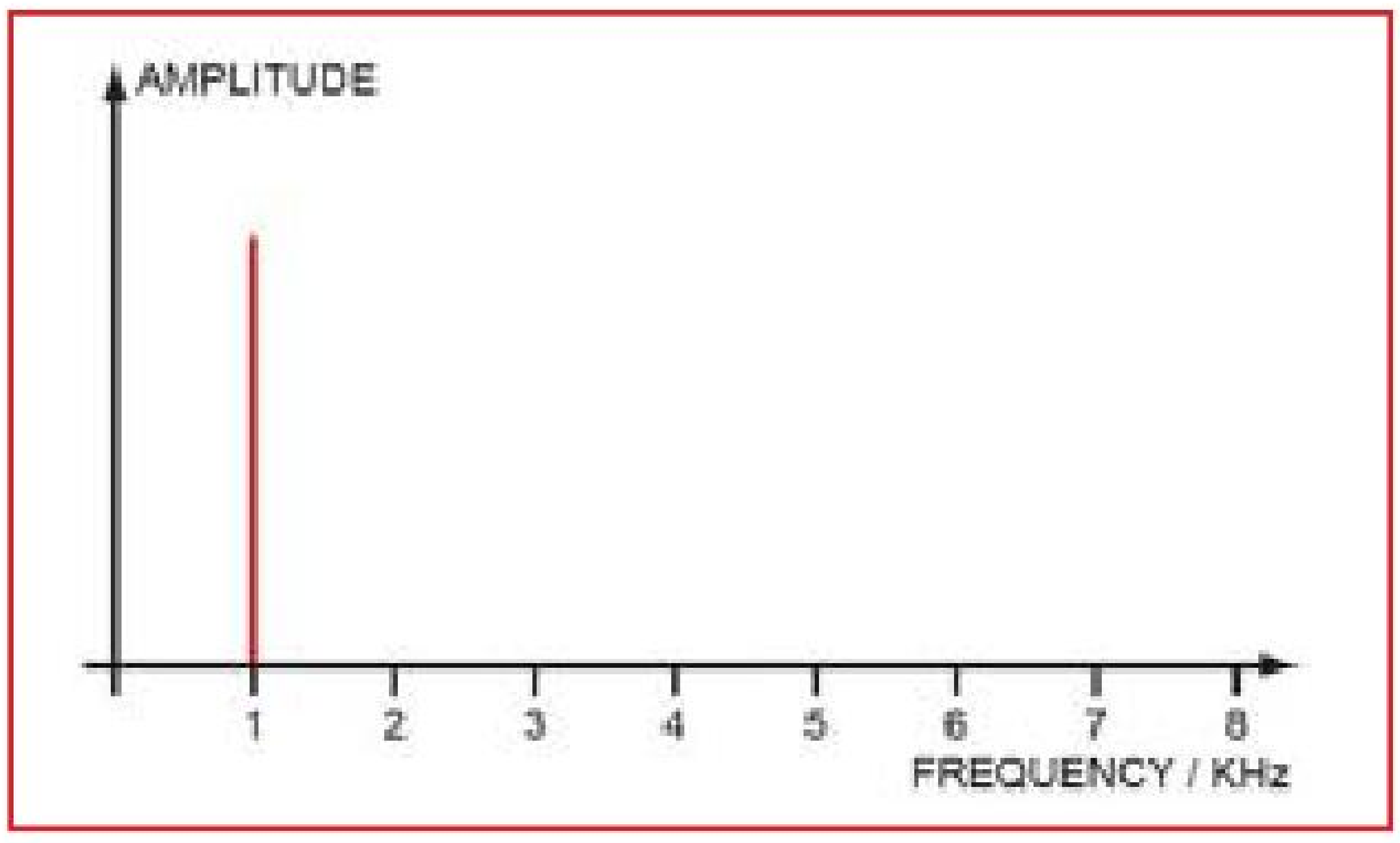


Fig.8. Spectrum of a 1kHz sinewave

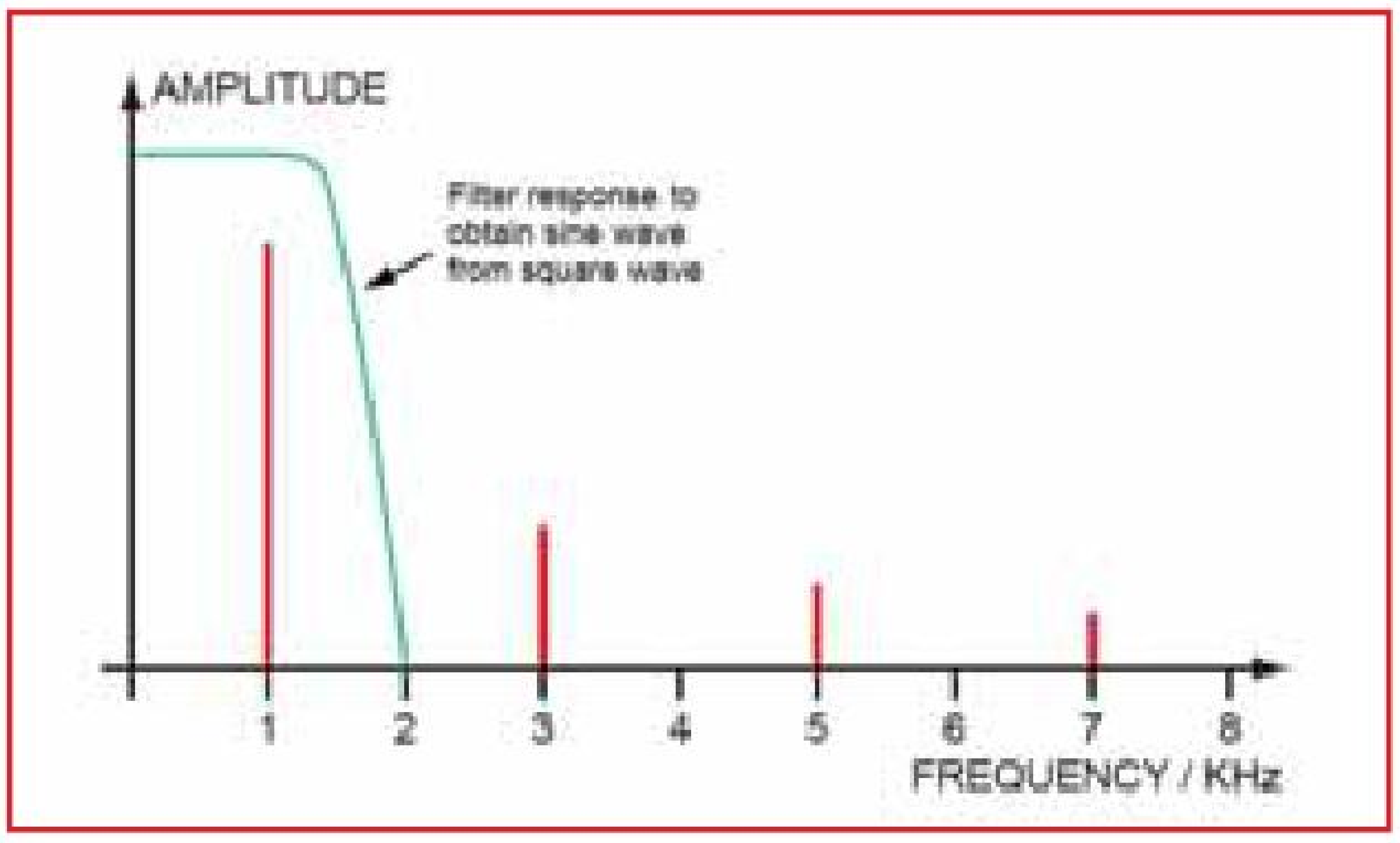


Fig.9. Spectrum of a 1kHz square wave showing the filter response required to convert it to a sinewave

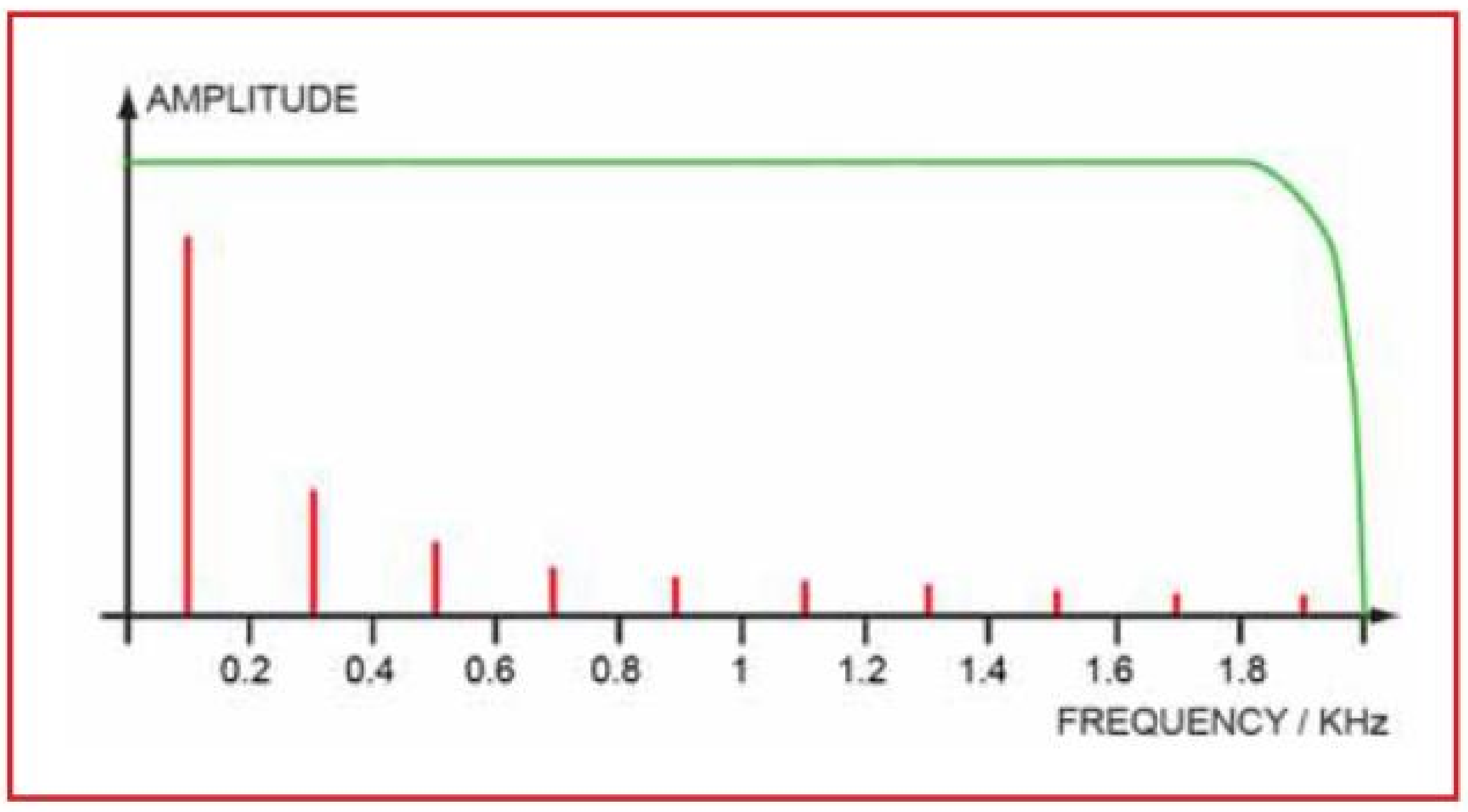


Fig.10. Spectrum of a square wave at on tenth of the frequency of Fig.9. The same filter will not remove enough harmonic content to produce anything like a sinewave (single frequency) output

different amplitudes. For example, a square wave may be described as being at 1kHz, but this is just the fundamental frequency; there are other frequencies present too, at multiples (harmonics) of the fundamental frequency. This is illustrated in Fig.9, which shows the spectrum of a square wave.

It follows from this that if we pass a square wave through a low-pass filter, chosen so that is only passes the fundamental frequency, the output will be a sinewave. The required filter response is illustrated on Fig.9. Inputting a 1kHz square wave into the filter from Fig.1 will produce a sinewave output. This is easily verified by simulation in LTSpice.

If we keep the same filter as shown in Fig.9, but reduce the frequency of the square wave by a factor of ten (so the fundamental is now 100Hz) we get the situation depicted in Fig.10. Now, many of the frequencies of the square wave are within the pass-band of the filter and, therefore, the filter output will be much closer to a square wave than a sinewave.

Filter frequency

This is what is happening in Agustín's circuit. The filter operates at a fixed frequency, and so as the input fundamental frequency is reduced, the filter is less effective at removing the harmonics and the output becomes less sinusoidal. There are two basic approaches to solving this. The first is to change the filter frequency in accordance with the required output frequency, and the second is to use a fixed sample rate for the digital sinewave.

In the first option we use the principle from Fig.9. We only need to generate a square wave. This keeps the digital circuit simple (no Johnson counter) and no DAC is required.

The more difficult issue is creating a filter which tracks the square wave frequency correctly, so that it always removes the harmonics as the square wave frequency changes. This is difficult to do with an analogue filter such as that in Fig.1, but is more feasible with a switched capacitor filter chip, where the cut-off frequency can be controlled by the clock frequency, which can also be related to the square wave.

The second option is to keep the sample (clock) frequency the same for all generated frequencies and use a fixed filter. The filter design is then straightforward – the one in Fig.1 would be sufficient, but the digital waveform generation is more complex. If we assume the situation in Fig.2, for the 900Hz sinewave, is fine and keep the 11kHz clock frequency, then the digital sinewave for 90Hz output (relating to Fig.4) would also use an 11kHz clock. This would require 120 steps in the sinewave, each with an accurate sinewave voltage. Similarly, a 9Hz sinewave (relating to Fig.5) would require a 1200-step digital sinewave at 11kHz.

Creating a waveform like this using the approach used in Fig.1 is probably impractical; however, it can be done in other ways. The sinewave values can be stored or calculated as binary values and passed to a conventional DAC to generate the waveform.

This approach also has the advantage of being able to generate wave shapes other than sinewaves, which cannot be done using a filtered square-wave. In practice, doing this is not quite as simple as it might seem from this quick description, but we will look at that in more detail next month.

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Egg Timer – *Well laid*

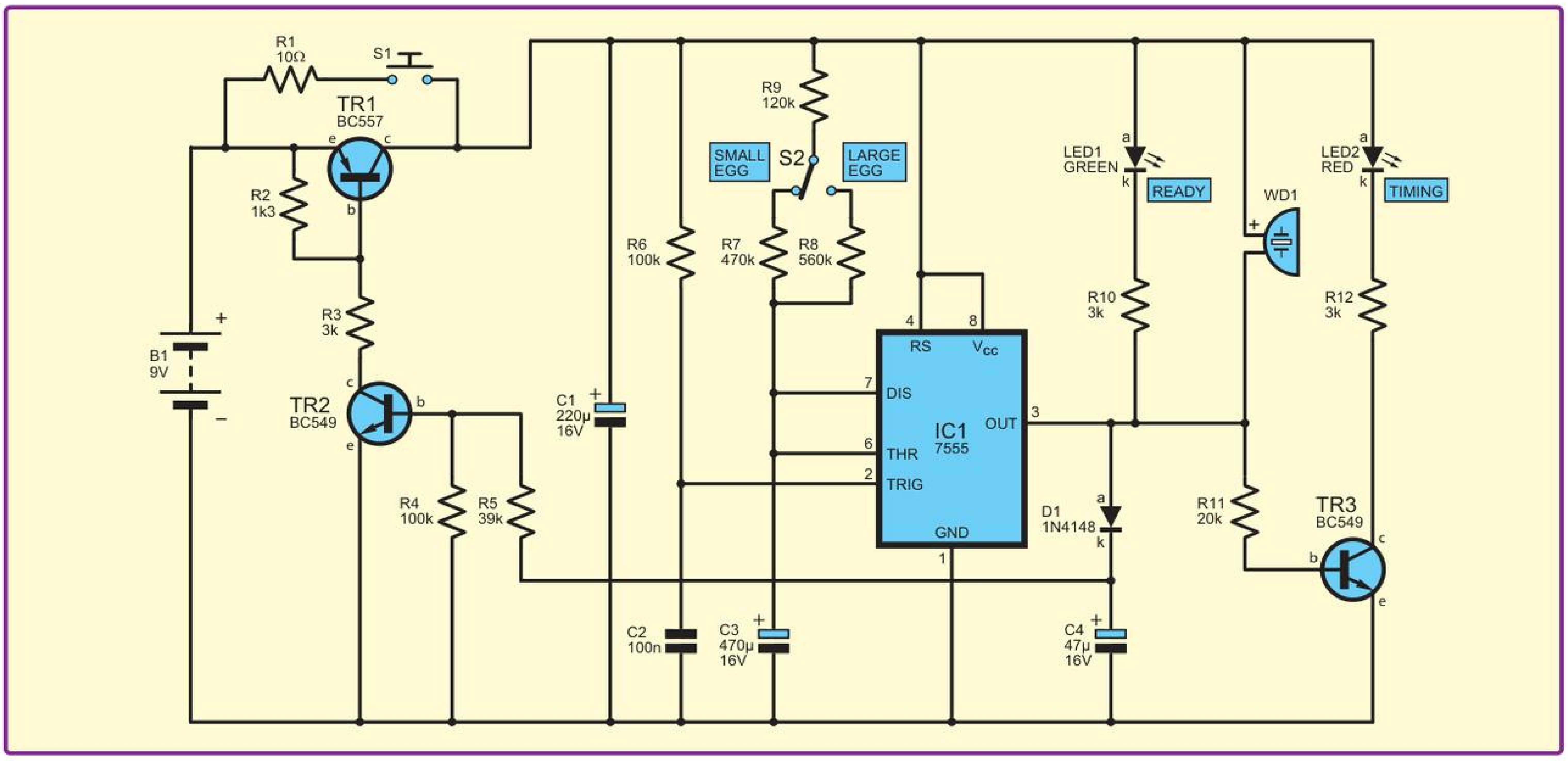


Fig.1. Circuit diagram for the Egg Timer

MY inspiration for this design came from the Egg Timer circuit published in Part 11 of Teach-In 2011 (EPE Sept 2011). I was particularly inspired by the comment from Mike and Richard Tooley that their circuit could be made practical by the addition of an on/off power switch; the idea being, to make it possible to shut off the buzzer when required.

My design (Fig.1) removes the need for a power switch by automatically latching power to the circuit when a momentary action switch (S1) is pressed to activate the timer. At the end of the timing period, when the egg is cooked, a buzzer (WD1) sounds, after which power is automatically removed from the circuit, silencing the buzzer and leaving the circuit ready to be activated again when next required.

When switch S1 is briefly pressed, power is applied to IC1, a low power 7555 timer. At this time, IC1's Trigger input (pin 2) is momentarily held low by capacitor C2, triggering the timer and sending IC1's output high. This initiates three actions. First, capacitor C4 charges up, via diode D1, to be close to the positive supply rail, which applies voltage to the base (b) of NPN transistor TR2, switching it on. The effect of this is to switch on PNP transistor TR1, thus latching power to the circuit.

Second, voltage is applied to the base of *NPN* transistor TR3, switching it on and illuminating LED2, the red 'Timing' LED. Third, capacitor C3 starts to charge via resistor R9 and either R7 or R8, depending on which way switch S2 is set.

When the voltage on capacitor C3 reaches 2/3 of the supply voltage, the timing period terminates and the egg is cooked to requirements. This means that switch S2 selects one of two available timing periods. My personal preference is for eggs to be cooked half way between soft and hard boiled. Therefore, I have selected values for R7, R8 and R9 to give a choice between timing periods of either about five minutes or about six minutes to cater for either large or small eggs.

A circuit builder would need to calculate, using the 555 monostable timing equation, T=1.1RC, his/her own values for R7, R8 and R9, the values reflecting the required egg cooking time. Component variations from ideal, such as capacitor tolerance and capacitor leakage current will introduce an error into this calculation. Leakage current can become significant when high values of timing resistance are employed.

When the timing period ends, IC1's output goes low. This again initiates three actions. First, transistor TR3 switches off, extinguishing the red 'Timing' LED. Second, the green 'Ready' LED1 illuminates and buzzer (WD1) starts to sound. Third, D1 becomes reverse biased, leaving capacitor C4 to slowly discharge via resistor R5 into the base of TR2, and also through resistor R4.

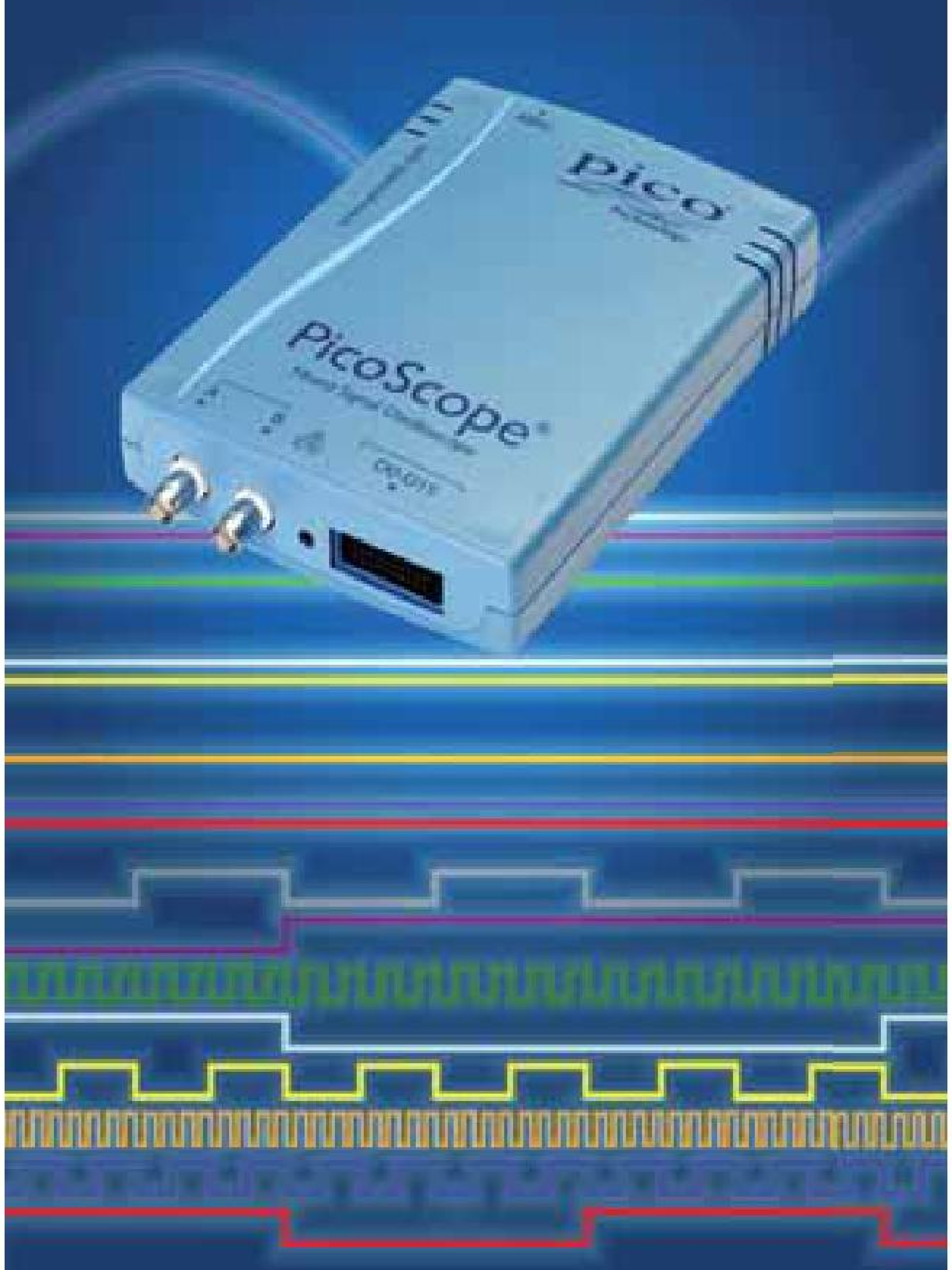
After a period of about five seconds, capacitor C4 has discharged down to about 1V, resulting in the voltage at the base of TR2 falling to below 0.7V. Hence, TR2 switches off, switching off TR1 in the process. This removes power from the circuit, silencing the buzzer. Resistor R4 makes sure that C4 completely discharges, thus ensuring that TR1 and TR2 are both firmly switched off.

It is apparent that the timer doesn't need to be touched again after it is initially triggered by pressing the push-to-make, momentary action switch S1.

The reason for driving the red 'Timing' LED via a transistor and not directly from IC1's high output is that, if driven directly from pin 3, I found that IC1's output would be loaded down far enough to develop sufficient voltage across the buzzer for it to sound during the timing period, albeit quietly.

I selected low current (2mA) LEDs for LED1 and LED2 to help prolong battery life. Resistors R10 and R12 program this low current.

Chris Hinchcliffe, Dorset



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Including a PICkit 3 for quick programming, this kit provides a platform for general purpose development and gives you the ability to develop code for any PIC12F1XXX/PIC16F1XXX microcontroller. Quick and easy development is ensured with the integrated functionality, including: prototyping area, LCD control, system current monitoring, temperature sensing, real-time-clock, LED drive, button control, and BLDC motor control.

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CLOSING DATE

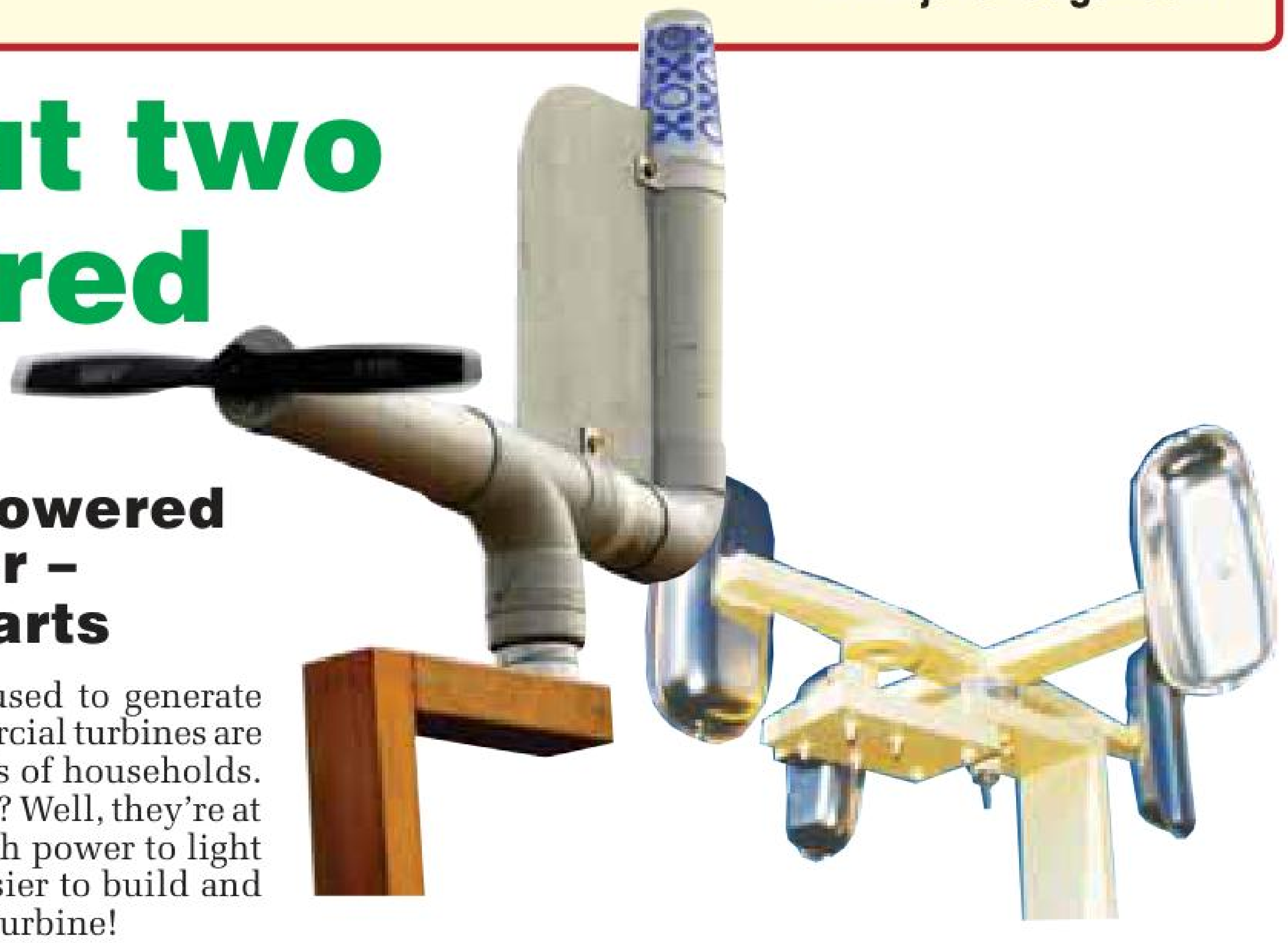
The closing date for this offer is 28 February 2012

Recycle It!

BY JULIAN EDGAR www.julianedgar.com

Not one, but two wind-powered devices

Build a low-cost wind-powered beacon or an LED flasher – using mostly recycled parts



WIND TURBINES are being increasingly used to generate green, renewable electricity. Many commercial turbines are huge, and generate power for tens of thousands of households.

And the wind generators covered in this story? Well, they're at the opposite end of the scale, producing enough power to light some high intensity LEDs! But they're a lot easier to build and install in your backyard than a full-size wind turbine!

A beacon of light

The first project (this month) consists of a horizontal axis, self-contained, wind-powered light. It uses a housing made from plastic pipe and fittings. At the front-end is mounted a stepper motor (acting as an alternator) and rotor (an ex-model aircraft propeller). At the other end is the tail vane, and on top of the tail vane is a glass diffuser, within which is an LED light. The design pivots on a vertical axis, allowing it to automatically face into the wind.

When the wind blows, the alternator is turned by the propeller and the LED illuminates – and stays on as long as the wind is blowing. The project is, therefore, a self-contained beacon – no cables down to ground level, thus avoiding the need for slip-rings.

There is room within the plastic pipe housing to add rechargeable batteries, a flasher circuit and so on, allowing the project to be modified to suit specific applications. For example, by adding the appropriate electronics, the project is easily made into a wind-powered, battery backed-up light that illuminates only at night.

Magnetic energy

The second project (next month) is even simpler – and can probably be made for less than £10. Its driving assembly rotates around a vertical axis, the wind being caught by whatever cups or bowls you can salvage.

This design flashes a single high intensity LED, with the rate of flashing determined by the wind speed. It is achieved by the use of two magnets that rotate past a coil whenever the wind is blowing. Other than the LED and the coil, no electronics are used.

The two projects draw heavily on recycled goods – including an old VCR, printer, microwave oven and beard trimmer – and recycled timber and plastic pipe.

WIND-POWERED BEACON #1

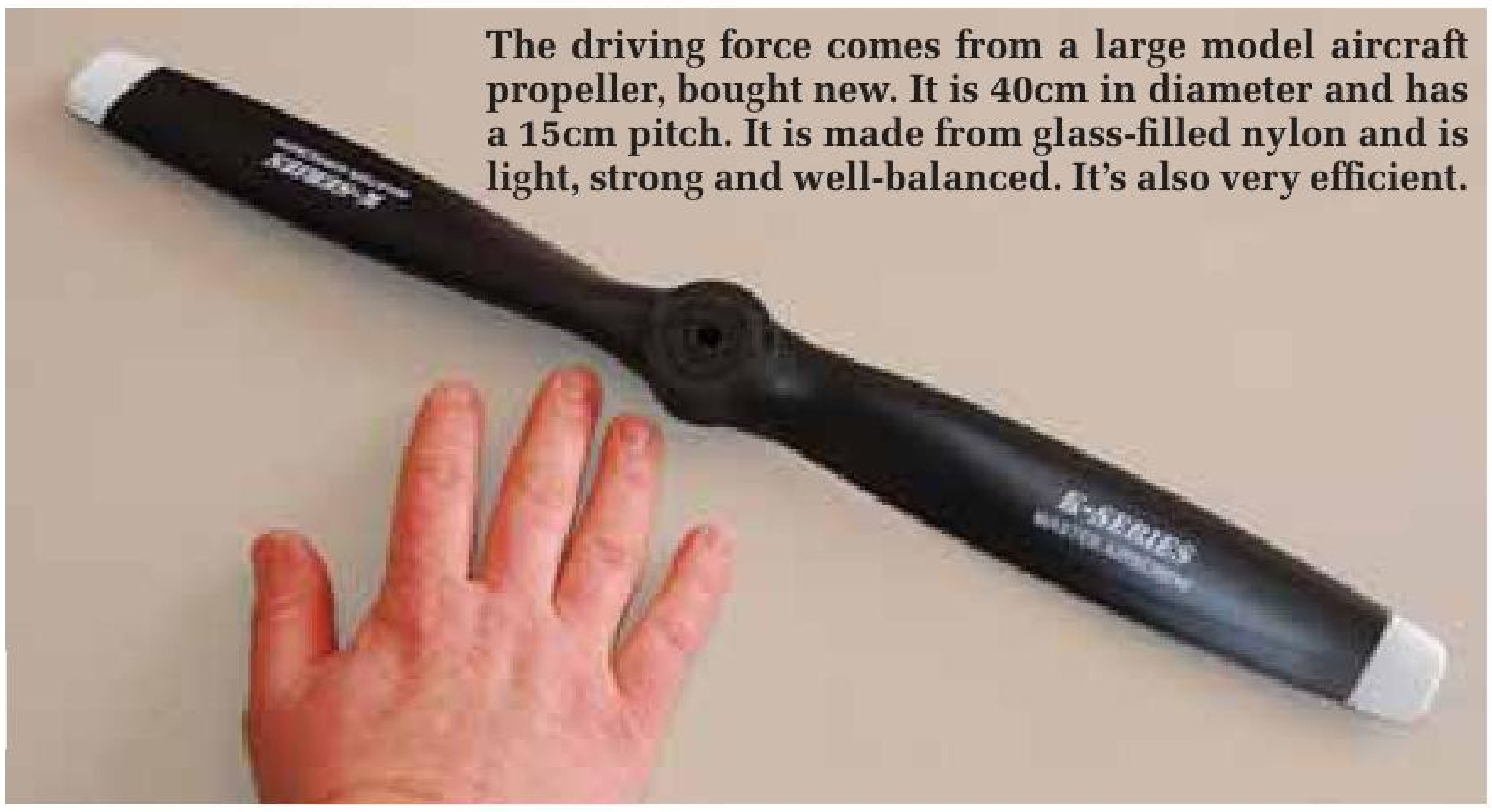
TO BUILD this tiny wind turbine, you'll need some kind of electrical generator and a rotor that will spin when subject to the wind.

Rotor blade

For the rotor, I used the largest model aircraft propeller that I could find. This proved to be 40cm (15¾in) in diameter, and the one bought had a 15cm (6in) pitch. (That is, if the air were solid, the propeller would 'screw' its way forward by 15cm each time it turned one full rotation.)

Using a model aircraft propeller results in much higher efficiency than using, for example, a salvaged fan. This is because model aircraft propellers are well designed – they have to be or else no modeller would buy them!

To put this another way, modellers are very well aware of how much power they



The driving force comes from a large model aircraft propeller, bought new. It is 40cm in diameter and has a 15cm pitch. It is made from glass-filled nylon and is light, strong and well-balanced. It's also very efficient.

have available from their tiny internal combustion and electric motors, so if their aircraft has poor performance when fitted with a certain brand of propeller, that brand soon gets a bad reputation. Few, if any, people make those sorts of detailed comparisons of the efficiencies of different domestic fans! Model aircraft propellers are also light and well balanced.

The propeller purchased is made from glass-filled nylon, is branded 'Master Airscrew', was made in the US, and cost about £10 from a modelling shop.

Generator

For the generator (or in this case, the alternator), I used the brushless DC stepper motor salvaged from a laser printer. Unusually, this was a three-wire design, but a four-, five- or six-wire stepper motor can also be used.

In addition to the propeller and stepper motor, I also used a video drum assembly salvaged from a domestic video cassette recorder; plastic pipe and fittings; a sheet of thin-gauge steel salvaged from the lid of a VCR; a frosted drinking glass (bought from a gift shop) and some other miscellaneous components.

Attaching the rotor

The aircraft propeller needs to be a good fit on the shaft of the alternator. The stepper motor salvaged had a small (but quite long) toothed cog pressed onto its shaft. By adding a thin plastic sleeve, the propeller became a push-fit onto the cog. (Note: the propeller needs to be exactly 'square' to the shaft and very firmly attached. Model shops have adaptors to match aircraft props to a range of shafts – check these out when you're buying the propeller.)

Before attaching the propeller, you can, if you wish, place a small O-ring on the shaft, leaving as small a gap as possible between the O-ring and the front face of the stepper motor. This will prevent water from entering the front bearing – the surface tension of the water will stop drops passing through the tiny space.

The diffuser for the light uses a frosted drinking glass. The glass is mounted upside-down, with the LEDs placed at the bottom and shining upwards. Some crumpled aluminium foil in the base (now top) of the glass reflects and diffuses the light.

Remember to organise your mounting system *before* gluing the rotor in place – more on the mounting in a moment.

Quick testing

In order to get a feel for how well the chosen propeller rotor would work with the salvaged stepper motor alternator, I built, from scrap wood, a relatively rough assembly to support the stepper motor with propeller attached. This allowed me to see what strength of wind was needed to get the rotor turning, and how much power I was likely to be able to gain from the alternator. This step is also good in that you can see how high the assembly will need to be mounted before it will be effective.

The stepper motor is used as an alternator. This part was salvaged from a printer and uses a two-phase (3-wire) design. However, more common steppers with a higher number of connections can also be used. Note the presence of the cog that makes attaching the propeller rotor easier.

In my case, a corner fence post on my sloping, semi-rural block was sufficiently exposed that the unloaded assembly would spin in even light breezes; I therefore decided that a tall tower would not be needed.

In this initial testing, I connected a 10mm high intensity LED directly to a single phase of the stepper motor (just trying different combinations of the wires until I got a pair that illuminated the LED with a quick turn of the rotor). Connected like this, the LED will be driven by an AC waveform (but it will still light) and will not have any form of current limiting. However, it is the quickest and easiest way to see what results you're likely to get.

If the LED lights in moderate breezes, you can be assured that once you use all phases of the alternator (not just one phase), you'll be able to get better results from the final installation. On the other hand, if you can't light even one LED connected in this way, it's unlikely that your project will be a success. (Of course, if the LED is immediately 'fried' you'll know the potential power output is great!)

Note: be extra careful not to contact the moving rotor. Model aircraft propellers used in this way can rotate extremely rapidly – fast enough that they disappear into a blur that may not be apparent without a careful examination.

PERFORMANCE

Project #1 (that's the wind generator with model aircraft propeller and the frosted glass light beacon) needs a decent breeze to really get it going. However, what prompted the project in the first place was my moving to an area so windy that a large-scale commercial wind farm is just up the road! At speeds I'd estimate at over about 15 km/h it starts to illuminate the beacon, and in higher wind speeds it glows very brightly.

On the other hand, Project #2 (wind-powered flasher) will work in even a faint breeze – say anything above 5km/h. I have the high intensity LED aimed at my kitchen window from about 10m away, and at night it is oddly disconcerting to see the regular bright flash coming from the garden – especially when you think that there are no batteries, no flashing circuit and no control system!

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month, we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up, but you get the idea . . .)

So, if you have some practical ideas, do write in and tell us!

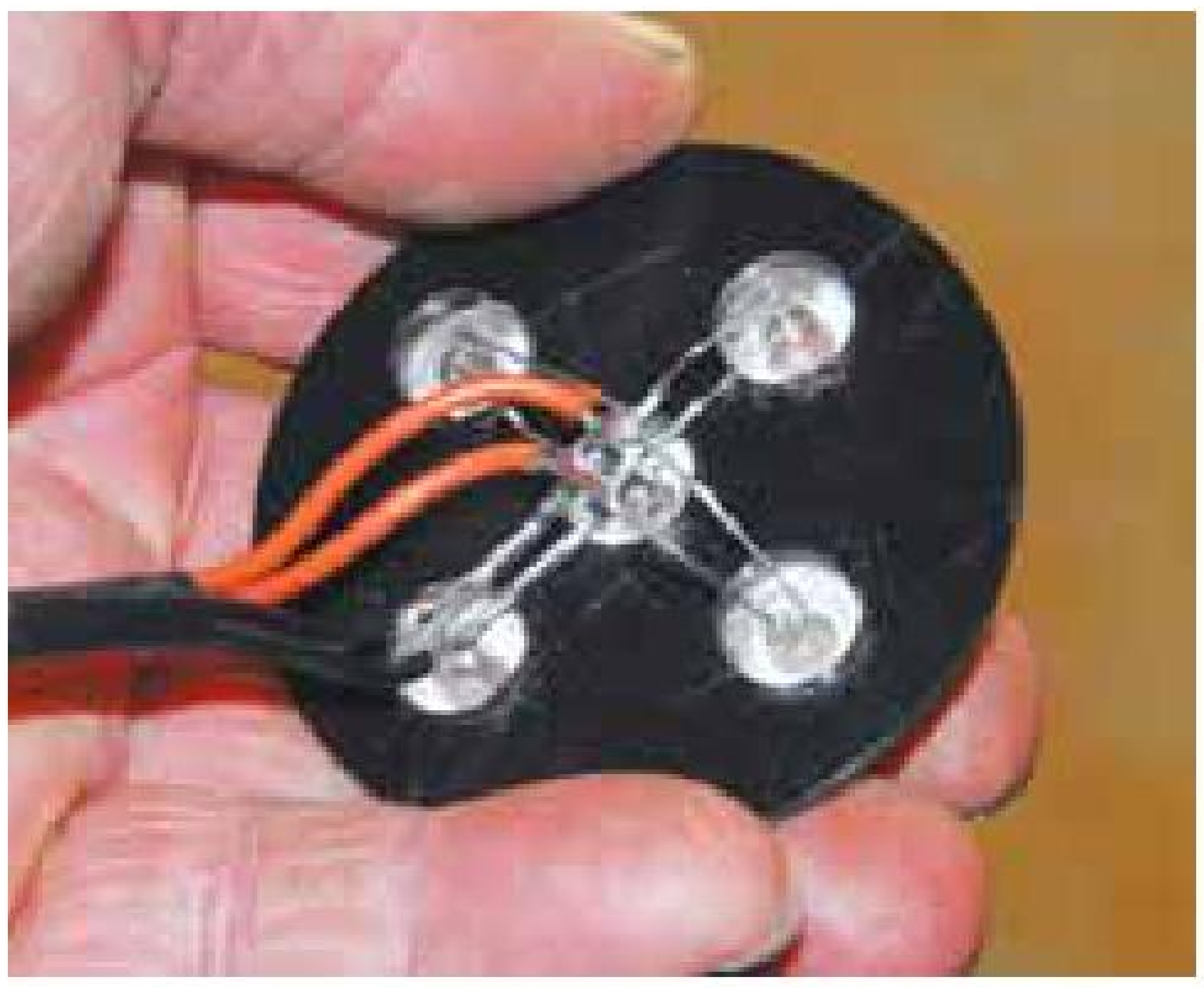
Beacon housing

After testing the wooden mock-up, the final housing was built from 65mm plastic pipe and fittings.

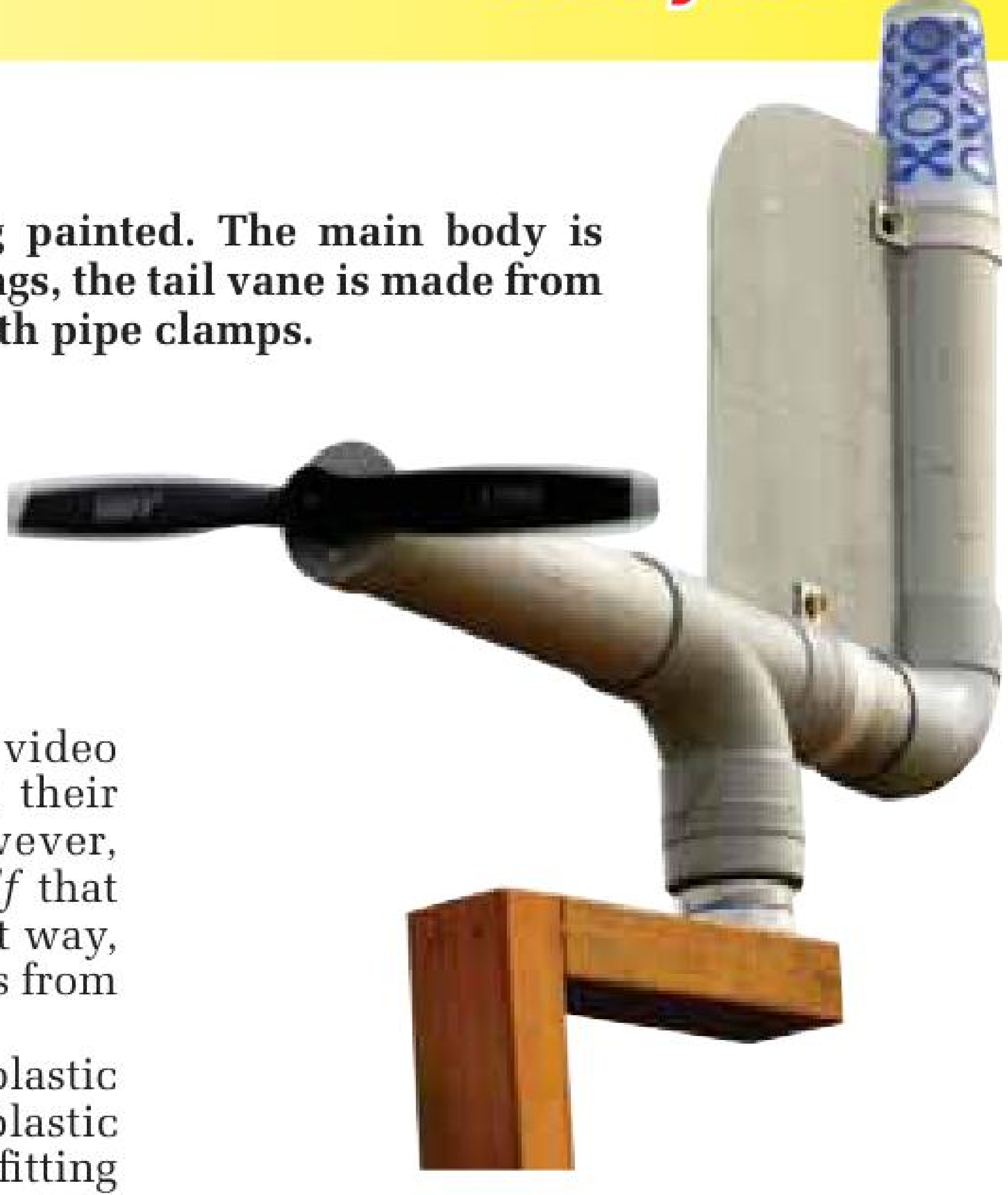
As the photos show, the housing consists of a T-shaped fitting that on its lowest leg connects to a plastic end-cap. Attached to this end-cap by screws and nuts is the top part of a video drum assembly salvaged from a VCR. The lower part of the video drum, which contains the bearings, is attached to the mast support by means of long wood screws.

The video drum needs to be disassembled and new holes drilled for the upper and lower attachment screws. The video drum therefore forms the vertical axis bearing, allowing the assembly to pivot into the wind.

The five 10mm high-intensity LEDs are mounted in a disc of plastic. The disc is held in place with a metal bracket salvaged from the headlight of a car. (You could use glue.) In this picture, you can also see the bracket that surrounds the pipe and helps to hold the metal wind vane in place. The inverted frosted glass beaker sits on top of this bracket and is held in place with silicone sealant.



The LEDs are wired in two groups of three parallel LEDs and two parallel LEDs. Each group is driven by one phase of the stepper motor, with current regulated by two dropping resistors.



The finished design before being painted. The main body is formed from plastic pipe and fittings, the tail vane is made from sheet steel and is held in place with pipe clamps. The assembly pivots on a bearing taken from an old VCR and the rotor is a large model aircraft propeller. The glass beacon at the top of the tail lights-up when the wind blows.

There is space within the body to add rechargeable batteries, flasher circuits and so on.

Previously, I have used these video drums in a similar fashion, and their durability is outstanding. However, remember that it's the *lower half* that should contain the bearings – that way, the upper part shields the bearings from water ingress.

Extending backwards from the plastic T-adaptor is a short length of plastic pipe, followed by a right-angled fitting and another length of pipe that stands vertically. This section of the housing forms the support for the tail vane and also provides the mounting point for the frosted glass light beacon.

Mounted on the rear half of the assembly is a thin steel sheet, cut from the lid of the VCR. It is held in place with standard pipe clamps, usually used to hold the pipe against house walls. The steel sheet forms the tail vane.

At the front, the stepper motor is screwed to the inside of a plastic cap, with the propeller attached after mounting has been completed. A large O-ring was used between the cap and the stepper motor to prevent water entering the main housing. Silicon sealant could also be used.

The plastic cap, with the stepper motor on it, was then attached to another piece of pipe that spaces it forwards of the vertical pivot point. Make this length of pipe sufficiently long that the vertical pivot point is then at the centre of balance – that is, you want the nose section to balance the tail section, so reducing the load on the video drum bearings.

High fives

I used an electric, speed-controlled drill to spin the stepper motor, and on the basis of trial and error testing (connecting LEDs and seeing what happened!), I decided to use five 10mm, high intensity red LEDs. These are each designed to have a forward current flow of 50mA. To prevent the voltage drop that occurs across a rectifier diode, I chose to drive the LEDs directly from AC – that's the output straight out of the stepper motor. (This means the LEDs light every half-cycle, but at speed they appear to be constantly lit.)

By playing with different connections (LEDs wired in series and parallel, being driven from one or two phases) and using a multimeter to measure actual current flows, I chose to parallel three LEDs and drive them from one phase, and parallel two LEDs and drive them with the other phase. It was then a case of selecting two dropping resistors that gave a total current draw on each phase that reflected the required 50mA for each LED (ie, three LEDs = 150mA, two LEDs = 100mA).

Valid criticisms can be levelled at this arrangement (What? Driving LEDs off AC? Driving parallel LEDs through a single dropping resistor – what about LED-to-LED current variations?) – and you can, of course, use whatever alternative approach you want. I chose this approach because it was simple and it works very well!

If you are confused about the different phases mentioned in the above description, see the September 2006 *EPE* on hand-cranked LED torches. If you are then still confused, just play around with the wire and LED connections until you get a good result. The worst thing that will happen is that you'll blow the LED – and if you initially assess the results by spinning the stepper motor by hand, that's nearly impossible to do.

The five LEDs were mounted in a disc of plastic, which was then mounted in the upright section of plastic pipe. Over the top of the LEDs, I 'silcone'd' into place an inverted frosted glass beaker. Testing showed that best results came when some crinkled aluminium foil was glued to the inside of the top of the glass 'beacon' (usually the bottom of the glass). This reflected and scattered the directional light from the LEDs.

Finally, the completed assembly was given a couple of coats of paint.

Next month, I'll show you how to build a Wind-Powered Flasher

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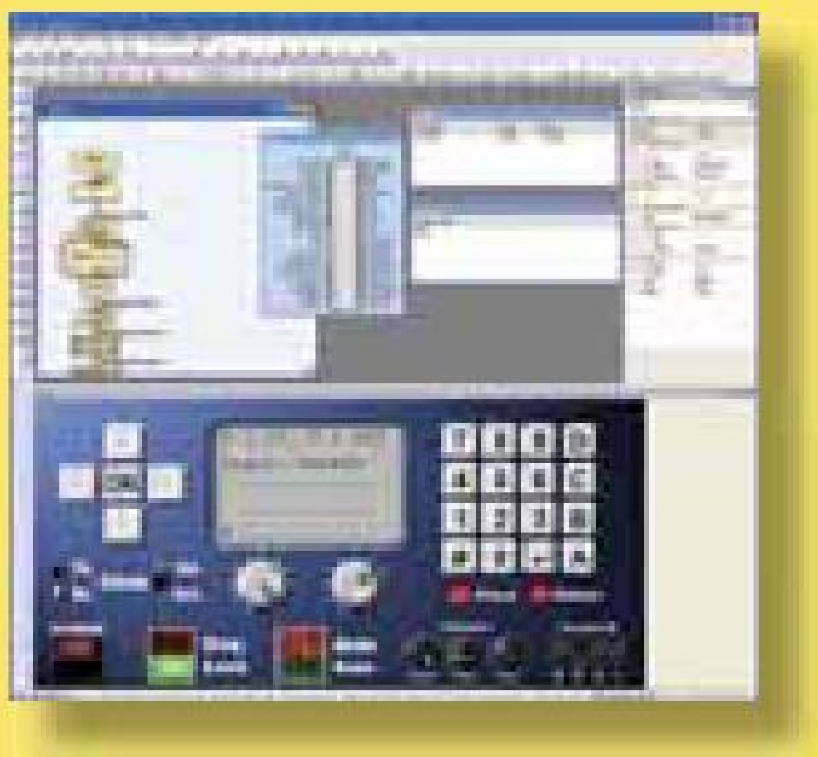
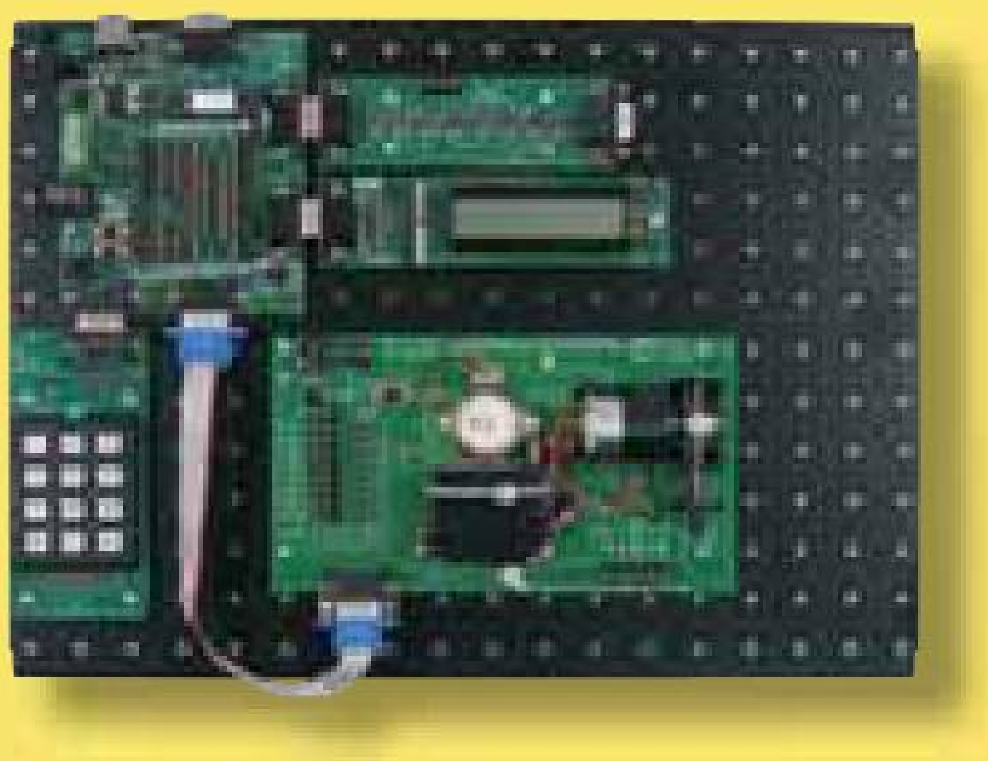


Design

Flowcode contains standard flow chart icons and electronic components that allow to you to create a virtual electronic system on screen. Drag icons and components onto the screen to create a program, then click on them to set properties and actions.

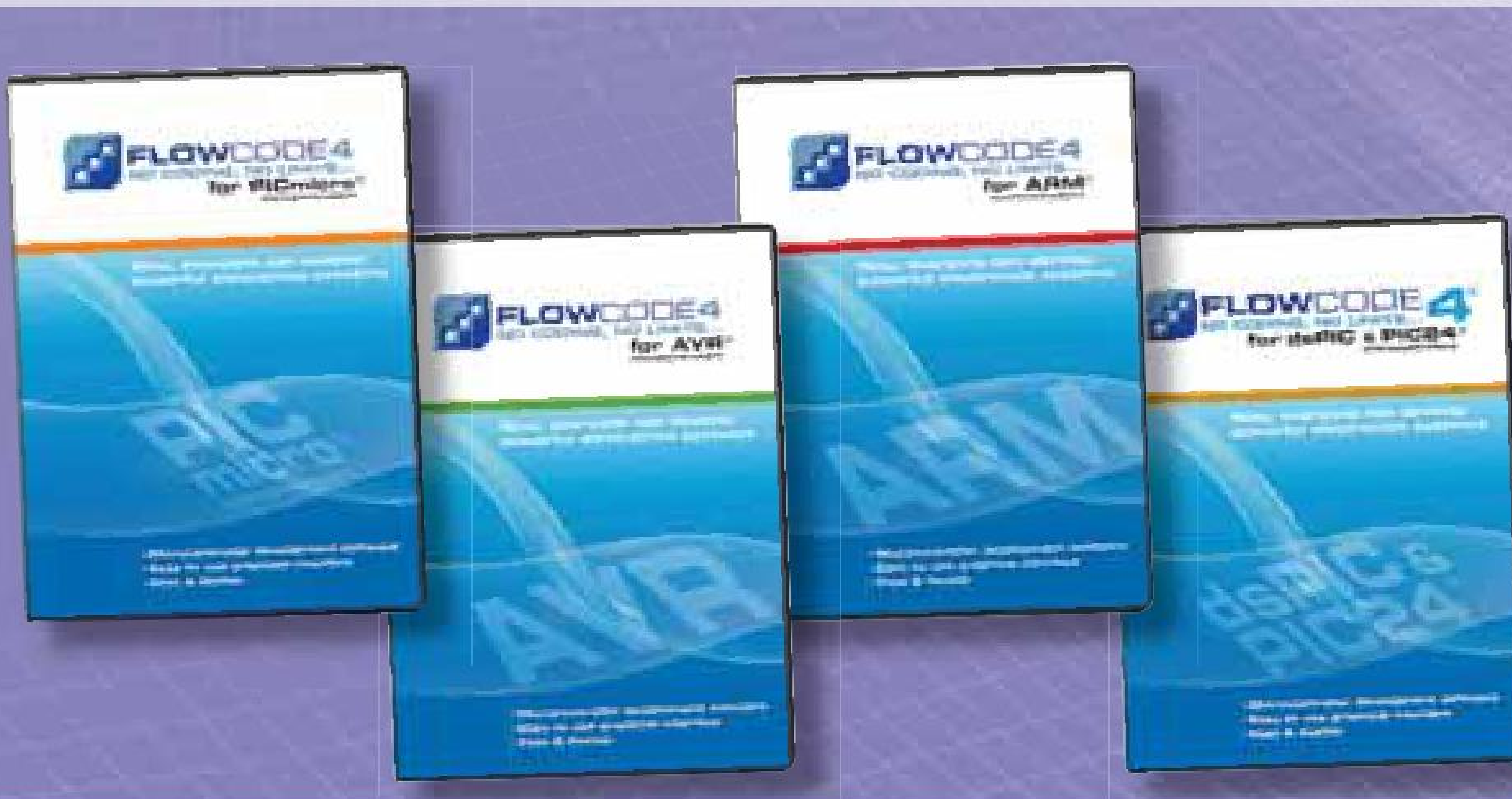
Simulate

Once your system is designed you can use Flowcode to simulate it in action. Design your system on screen, test the system's functionality by clicking on switches or altering sensor or input values, and see how your program reacts to the changes in the electronic system.



Download

When you are happy with your design click one button to send the program directly to your microcontroller based target. Targets include a wide range of microcontroller programmers, upstream E-blocks boards, the Formula Flowcode robot, the MIAC industrial controller, or your own system based on ECIO technology.



matrix FlowKit

FlowKit

The FlowKit can be connected to hardware systems to provide a real time debug facility where it is possible to step through the Flowcode program on the PC and step through the program in the hardware at the same time. The FlowKit can be connected to your own hardware to provide In-Circuit Debug to your finished designs.

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Prices for each of the CD-ROMs above are: ***(Order form on third page)***

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Hobbyist/Student	**£45.95**	**inc VAT**
Professional (Schools/HE/FE/Industry)	**£149**	**plus VAT**
Professional and Flowkit bundle	**£175**	**plus VAT**

PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

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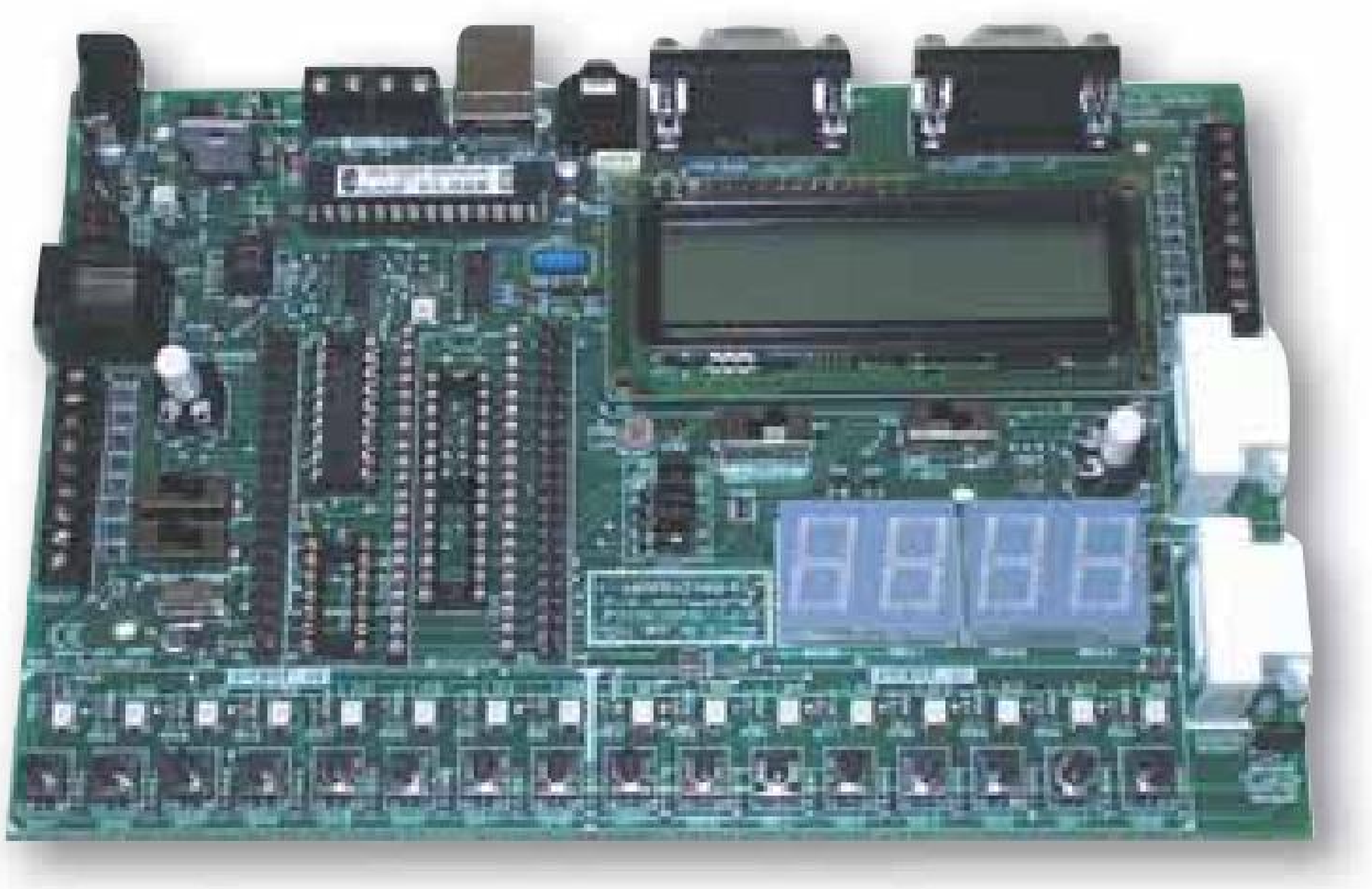

£161 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

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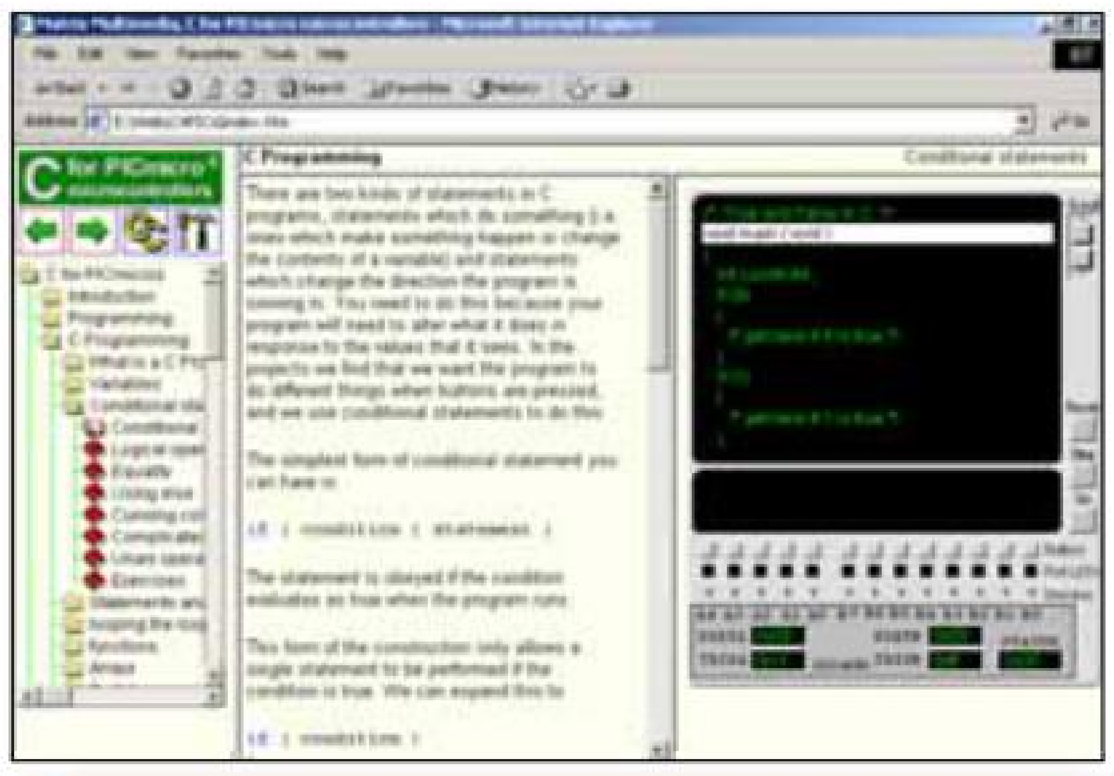

Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

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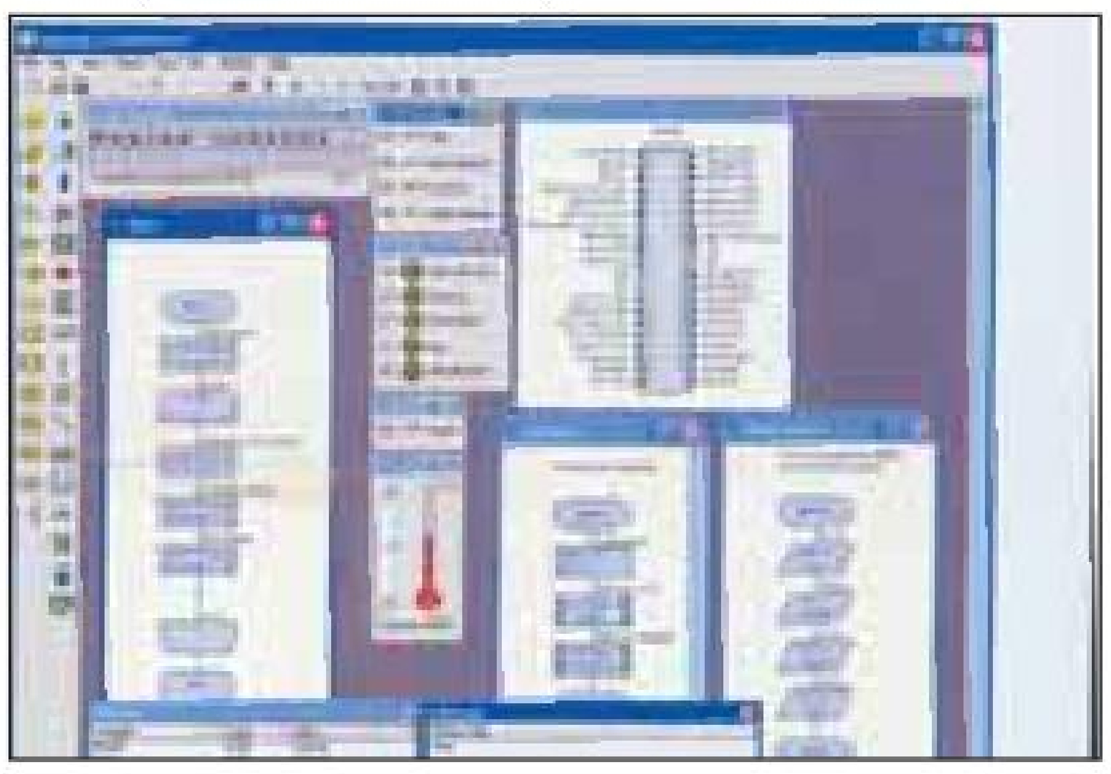
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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Professional 10 user (Network Licence)	**£350**	**plus VAT**
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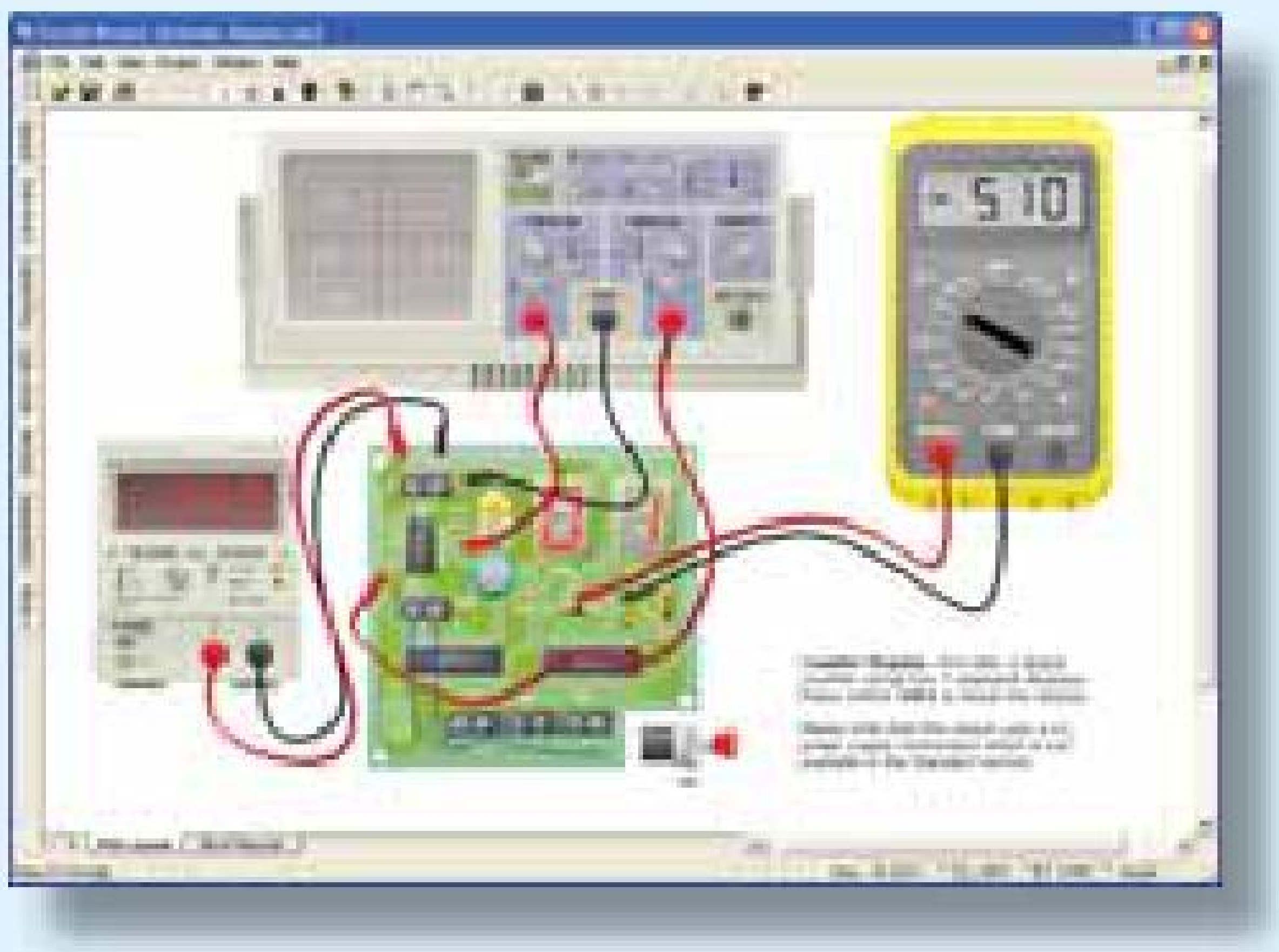

This software can be used with the *Teach-In 2011* series (and the *Teach-In 4* book).
Standard **£61.25** inc. VAT
Professional **£91.90** inc. VAT

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

EPE PIC RESOURCES V2

Version 2 includes the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

The CD-ROM contains the following Tutorial-related software and texts:

- EPE PIC Tutorial V2 complete series of articles plus demonstration software, John Becker, April, May, June '03
- PIC Toolkit Mk3 (TK3 hardware construction details), John Becker, Oct '01
- PIC Toolkit TK3 for Windows (software details), John Becker, Nov '01

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☐ **Professional + Flowkit**
☐ **Site licence**

Note: The software on each version is the same, only the licence for use varies.

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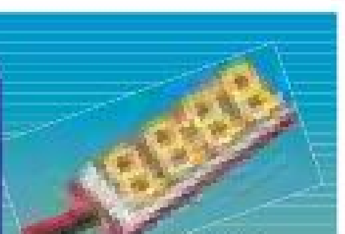

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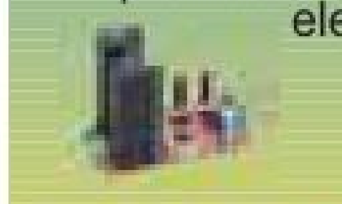

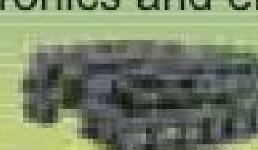

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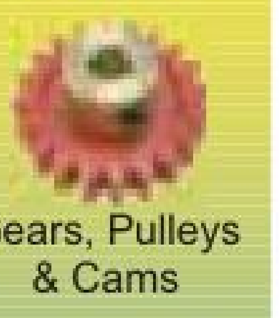

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NET WORK

by Alan Winstanley

Boxing clever

WELCOME to this month's *Net Work*, the column specially written to help *EPE* readers get more from the Internet.

Our remarkable *Web Server In A Box (WIB)* constructional project (*EPE* Dec '11), expertly designed by Mauro Grassi, shows how far the hobby has moved in the space of 15 years: we can now build our own dedicated server and connect it to the 'net with our own ADSL connection. The WIB server is controlled by firmware stored in a programmable dual-in-line microcontroller, a routine matter for today's electronics hobbyists.

Data is hosted on a cheap memory card, and the WIB can be used to monitor up to four analogue sensors and control up to four digital ports; the WIB can even email you when triggered by an event, and it can host personal websites too. Anybody with half-decent soldering skills will be able to construct a WIB successfully, and I am sure it won't be long before *EPE's* ever skillful readers are dedicating an *EPE* WIB to their own particular applications: be sure to write in and let us know.

The purpose of a server is to share information over a network. One application of the *EPE* Web In A Box would be to host photographs, operating like a digital photo gallery over the network. Other methods of sharing some Yuletide snapshots and videos include *Flickr* from Yahoo (free account has restrictions, or $24.95 per year for Pro), or *Picasa* from Google, with basic image editing. Online suppliers, such as **PhotoBox.co.uk**, also offer prints, photobooks, calendars and canvasses made from your online photo albums: an A3 calendar costs more than £18.00 ($30). The UK Tesco Photo Centre (**www.tescophoto.com**) offers calendars, mugs and canvasses made from your uploaded photos. Many of these services are integrated with Facebook and can be handled via a mobile phone. If you own a digital camera then it is worth choosing an online service to host your library online, ready to share them with friends and family in the holidays.

The perfect host

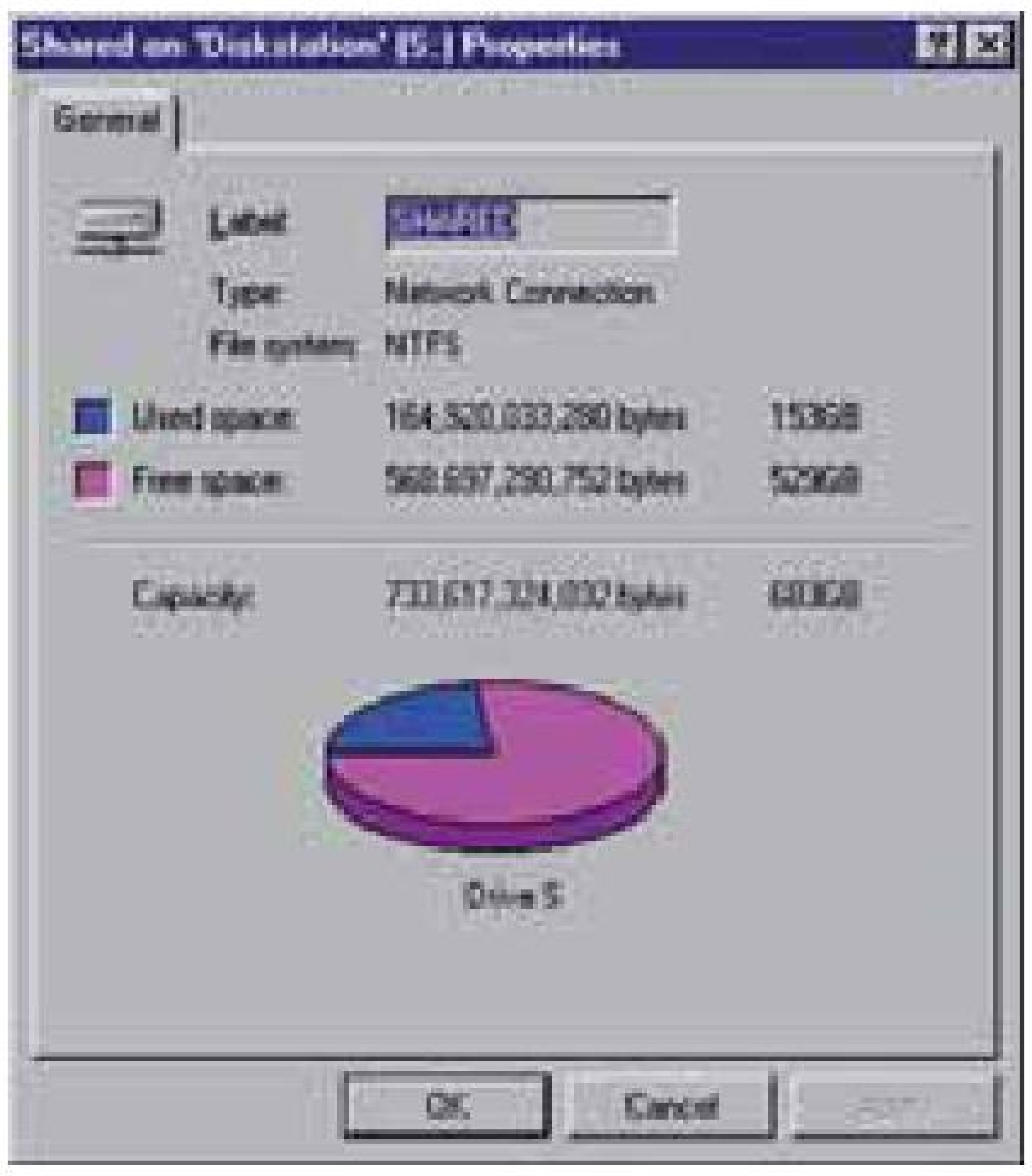
For those not wishing to build their own web server, there are countless choices for hosting web-based content online. Start by choosing the platform or operating system used by the server, which generally boils down to picking either LAMP (Linux/Apache/MySQL/PHP) or Microsoft Windows.

For many users, the differences will be indiscernible unless they are involved with scripting, database programming or bespoke coding. By default, I use Linux servers. A clue pointing to a Windows-based server is the use of dynamic .asp – Active Server Pages – rather than the .php pages beloved of Apache servers.

Some foibles that are familiar to Windows PC users carry over to a web server: importantly, Linux/Unix-based systems observe filename case-sensitivity. Windows PC users may be confounded by the fact that two web pages called **EPE_WIB.htm** and **epe_wib.htm** can co-exist in the same directory in a Linux/Unix system, but not in Windows. Some FTP software (eg, WS-FTP) can be set to force lower-case file names during transfer, and a good tip is to use lower-case filenames throughout when putting some web pages together.

Domain names are part of any hosting package and can be included with hosting or bought separately from commodity sellers such as Namecheap, GoDaddy or Namesco. In that case, simply point the domain's nameserver details towards your website host. When buying a domain, don't be deceived by 'teaser' headline prices and beware of the small print: some domain sellers unashamedly hide some costs including VAT, transfer-out or repeat/renewal costs, and domains can sometimes cost considerably more from 'year two' onwards.

Last, compare server disk space and bandwidth – disk space includes your email as well as web space, and bandwidth may include all traffic, including your own FTP sessions. The best way is sometimes just to suck it and see. A control panel allows email addresses to be configured, applications such as slideshows or forums to be installed with virtually one click, statistics to be checked, domains to be configured and more besides. If you're new to web hosting, then control panels are best used on a 'need to know' basis. Some hosts offer telephone support, while others respond by email only. In a saturated commodity market driven downwards by price, you get what you pay for.



Type: Network Connection
File system: NTFS
Used space: 164,520,033,280 bytes 153GB
Free space: 568,697,290,752 bytes 529GB
Capacity: 733,617,324,032 bytes 683GB

Paragon's NTFS Reader for Win98 allows NTFS volumes (here hosted on a Synology Diskstation) to be accessed by a Windows 95/98/Me system. Free for personal use.

Up the Amazon

Last month, I mentioned the challenge of exporting the .ts programme files from my Humax PVR on to a Windows PC, where I could edit and archive them onto DVD. I discovered that the PVR can copy programmes to a Linux ext3-formatted external hard disk, which I can then import into Windows. I found Disk Internals' freeware Linux Reader 2.0 for Windows perfect for this (**www.diskinternals.com**), though the free ExtBrowser FS from Paragon Software mentioned in December's column proved incompatible. As an aside, Paragon (**www.paragon-software.com**) also offers a useful NTFS Reader for Windows 95, 98 and Me systems – so I can use my network to access the files hosted on my NAS from a dedicated Windows 98 accounts machine (see screenshot). Mac users can buy Paragon's NTFS for Mac OS X 9.5 for $19.95, which promises full read/write access of NTFS volumes.

Using VideoRedo software (**www.videoredo.com**) for video processing I can cut the commercials, output an .mpeg or burn a menu-driven DVD. Next in my 'to-do' list is to configure my Contour Shuttle multimedia jog control (**http://retail.contourdesign.com**) to mimic the keystrokes of VideoRedo, which will allow for rapid editing of programmes. The Contour Shuttle works with many popular media or office programmes, and is currently listed by Amazon, where I also noted their range of 'Amazon Basics' no-frills items, including 100-packs of DVDs for under £15.00 with free delivery. Job done.

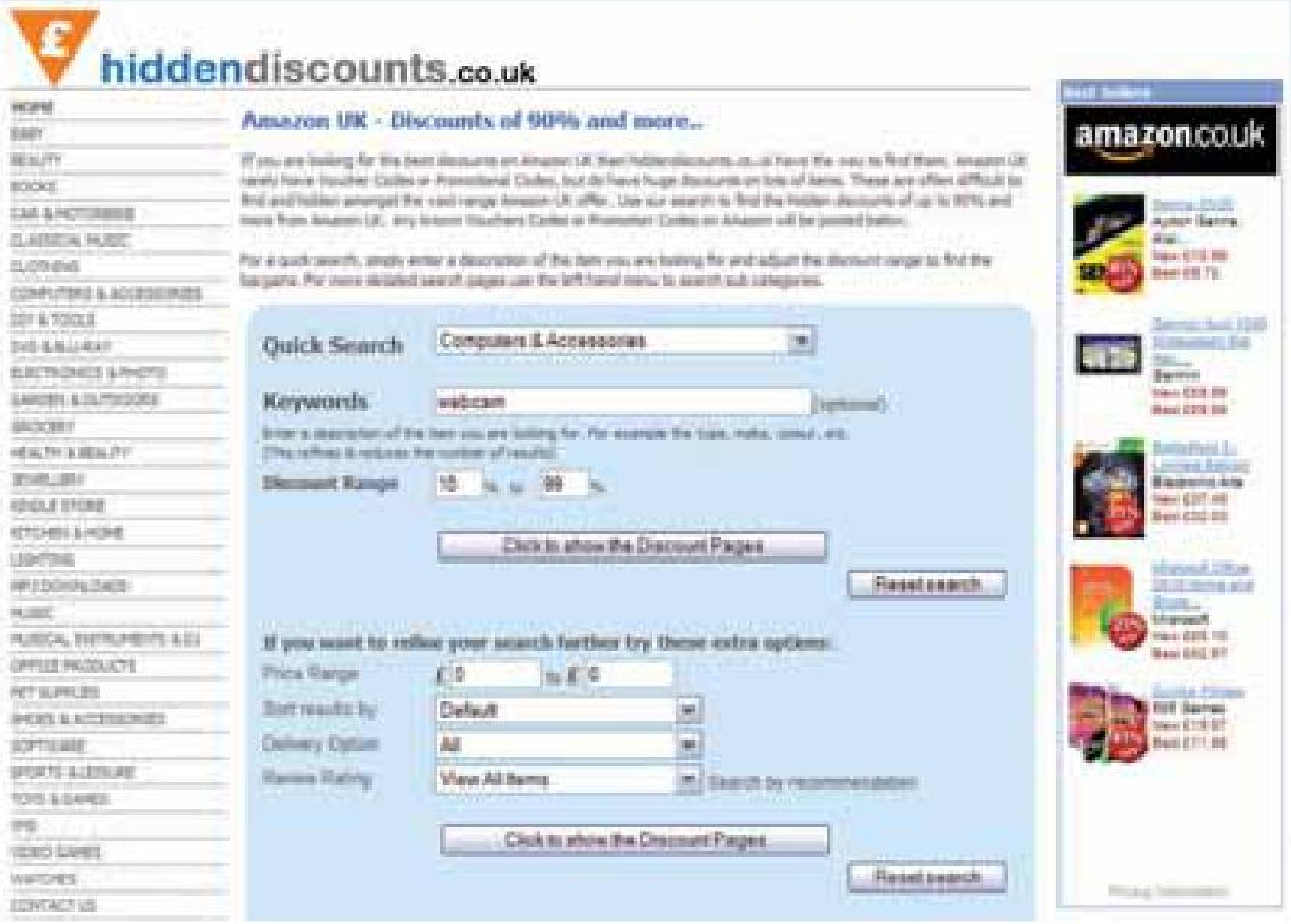
Back in the 1990s, when Amazon was little-known in Europe, the whole Internet industry was still fermenting and it is quite startling to realise that Amazon opened in the UK and Germany as far back as October 1998. Before then, waiting for Amazon's discount-priced parcels to arrive from the USA was quite a thrill, but Amazon's expansion attracted some adverse comparisons with the Internet-industry's meteoric 'cash burn' rate.

Some even questioned whether Amazon would even survive. The billions of dollars thrown at the Internet industry and the resulting turmoil beggared belief, but Amazon defied all 'nay-sayers' and skilfully navigated through the dot-com bubble era to become the all-embracing online store that it is today.

Compare this with the news that Best Buy Europe, a monolith of a US electronics retailer, has failed to make any headway in its UK programme. Killed off by a conjunction of bad timing and the recession, Best Buy plans to close all 11 of its retail superstores after just 18 months of trading.

Customer relationships

Depending on your privacy settings, Amazon carefully nurtures your website footprints to garner your interests and preferences. Before you know it, an email arrives suggesting similar products for you to consider: this is CRM (customer relationship management) in full swing. eBay too is moving the same way, by remembering your searches and populating its homepage with items that it thinks might interest you. eBay strong-arms its sellers (who are also billed for the privilege) into offering a quality service but, unlike online auction sites, Amazon offers a consistent shopping experience and it has quickly become the first port of call for the majority of online buyers looking for a fairly safe bet.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More than just a book-store, Amazon is an outlet for all manner of independent online sellers – anything from wedding tiaras to electrical appliances or groceries are now found here, either despatched direct by a supplier or via Amazon's fulfilment centre. Used book sales are a boon, too – some handy reference books covering some legacy software were delivered by Amazon for pennies, followed by some PC memory, a graphics card, and a carpet cleaner. I can view online all orders back to 1999, which is quite thought-provoking at times; I reflect on how time has flown and the cost of staying abreast of technology over the past dozen years.

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To get more out of Amazon, I suggest the site **www.camelcamelcamel.com** (choose your own country) which offers Amazon price drop alerts, and UK users should try **www.hiddendiscounts.co.uk** which unearths all manner of discounted prices and hidden bargains stashed away on Amazon UK.

Prime time

Only an ardent Amazonian would consider subscribing to Amazon Prime, which guarantees unlimited free one-day deliveries for a fixed annual cost, currently £49 per year. For once, it's an improvement over our US cousins, who must suffer a two-day service for $79 per year. For most buyers, Amazon's already attractive 'free delivery' option might suggest delivery in seven to ten days but goods frequently arrive within two to three days which is perfectly acceptable.

It has never been easier to shop around online and compare prices, but things can still go wrong, and so I will round off this month's column with a timely reminder about returns. In the UK, consumers (not businesses) enjoy a seven-working-day cooling-off period for most items bought at a distance (that's Internet, or MOTO/mail or telephone/fax order.) Some exclusions are auctions, bespoke or perishable goods, shrinkwrapped software and magazines.

Widely misunderstood is the fact that the seven-day cooling-off period relates to the first time consumers have an opportunity to examine the goods, which might be a few weeks after delivery if they are away on holiday. I have known such claims to be entertained a month after delivery. Consumers must usually pay for return carriage, but are entitled to a refund of the original postage.

That wraps up the column, and I hope you enjoyed reading *Net Work* for another year. I do appreciate all the feedback and kind comments that I receive from readers. I wish you all a safe and happy Christmas holiday and better prosperity in 2012. You can email me at: **alan@epemag.demon.co.uk**.

READOUT

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

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All letters quoted here have previously been replied to directly

Email: editorial@wimborne.co.uk

☆ LETTER OF THE MONTH ☆

Humax to PC file transfer

Dear editor

I've been reading (and enjoying) Alan Winstanley's *Net Work* ramblings, especially recent ones on The Humax HDR-FOX T2 PVR. I bought one of these gadgets back in April on the recommendation of a work colleague; all I can say is that it is 'magic'!

Like Alan, I found the Humax forum at **www.hummy.tv** to be a goldmine of information. I noticed in December's column that you wanted to get files off the PVR and on to the PC for backup. The PVR does indeed read from NTFS-formatted disks, but will not write to them. Alan said that to write to an external device it needs to be formatted ext3 (a Linux format). This isn't quite true. The HDR-FOX T2 will also write to a FAT32-formatted drive, such as the USB flash drives that we all seem to carry around nowadays.

There is one catch though – isn't there always? FAT32 can only hold a maximum file size of 4GB, a limit imposed by the FAT32 file system, not the Hummy. What this means is that if the recording is long, then it will be over 4GB in size on the Hummy. If you copy this to a USB pen drive, anything over the 4GB will be lost. (It just gets chopped off and the PVR doesn't warn you that you will lose data). I speak from experience here.

Still, for taking programme recordings from the Hummy, provided they are short (about one and a half hours or less) in SD recording mode, then it is very convenient, because good old Windows reads FAT32 drives in its sleep.

For files over 4GB (ie, long programmes) you do indeed need an ext3-formatted drive. For this, I use Parted Magic, available here:

http://partedmagic.com

http://sourceforge.net/projects/partedmagic/files/partedmagic/

It is downloaded as an ISO file and creates a bootable Linux-based CD (doesn't need installation on you PC) that can be used to create and format ext3 drives. It can also be used to create and format NTFS drives. Just make sure you are formatting the correct drive, especially if you have a lot of drives on your PC. (It's probably best to disconnect all the drives in your main PC before booting to the CD.)

For reading ext3-formatted drives on a windows PC I use Ext2 Volume Manager, available here:

http://www.ext2fsd.com

http://sourceforge.net/projects/ext2fsd/files/Ext2fsd

The Parted Magic Linux partition manager can even be used to create and format a 2TB hard drive to replace the 1TB drive that the PVR comes with (the PVR can only format up to a maximum of 1TB hard drive). I have also done this to my PVR for the extra storage.

I record old war films and any documentaries on World War II, especially items on Bletchley Park and the code breakers. Space is another interest of mine, so NASA Space Shuttle programmes and similar also get recorded and archived to the PC.

I got all the above information from the Hummy forum, which as I said earlier, is a goldmine.

Les Hadden, by email

Alan Winstanley replies:

Thanks for your feedback on last month's column, and I'm really pleased that you enjoy reading Net Work.

I've done some work with the Humax PVR, though so far I've stopped short of hacking into its firmware in case I get into bother with the head of the household!

By the way, we have similar viewing tastes, I too want to archive to DVD the current series of NASA's greatest missions, and the interesting item on Bletchley Park.

After experimenting with different storage hardware on my Humax HDR-FOX T2, I found that I could read media files on most of my USB memory drives and hard disks, but could not copy programme files to any them.

You mentioned NTFS, which could indeed be the root cause (no pun intended), as I could not copy to an NTFS external USB disk, though I could view JPEG files stored on it. I agree with you that FAT drives could also be used for copying, mindful of the Windows 4GB file size restriction you mention. Humax states that files can be read (only) from NTFS drives, but files can both be read and copied using ext3- or FATx-formatted drives.

Happily, I copied dozens of TV files to the same hard disk after allowing the Humax PVR to reformat it in (what turned out to be) ext3. Finding a Windows program that formats a partition as ext3 seems to be a problem. Paragon Partition Manager 11 Personal edition (untested) appears to do that, but the free edition does not, despite its PDF manual implying otherwise!

Thank you for suggesting the open-source formatting program Parted Magic, which I will try. I also agree with your advice about safeguarding precious hard disks prior to formatting anything. It is so easy to make a mistake with drive letters and damage a system disk accidentally.

As for importing TV files into Windows, Paragon's freeware ExtFS Reader proved incompatible: perhaps the Humax file encryption may be the cause, or a wrong ID that only a Linux system or Mac OS can change. Disk Internal's free Linux reader program works flawlessly though.

Much of this Linux nomenclature might be new to EPE *readers. Linux is a satisfying OS that gets better all the time, but it's probably anathema to much of the core* EPE *readership, which has flourished under DOS and Windows, and I admit I still have a lot to learn!*

Alan Winstanley
EPE online editor

Defending the AVO meter

Dear editor
As a long-retired calibration engineer, I must take issue with some of the comments made about the wonderful AVO 8 Mk 5. Early AVO meters, like the model 7, had their ranging resistors hand wound from Eureka resistance wire, but the later Mk 5s used a collection of 5% carbon resistors to make up the value. Fine in the short term, but even carbon film resistors tended to drift with age. However, the chief snag with the cheap digital meters on the market stalls is their dubious claims to accuracy, especially when inside them you see that the ranging resistors are often the cheapest 20% types, with no long-term stability at all. You don't find many AC voltage ranges on them and AC current ranges are even fewer.

At least with AVO meters on the AC ranges it was reasonably accurate, even if the AC waveform wasn't exactly a pure sinewave. This is more than can be said for the rectified guesswork of the cheap digital systems, and that's why they didn't have low voltage AC measuring facilities. The only advantage they do have is that they take almost no current out of the circuit being measured.

When these meters first appeared on the market they caused consternation among the calibration community because our equipment was required to be ten-times more accurate than the equipment being tested, and there was nothing on the market that could do this. Quite a few of the calibration equipment manufacturers fell for the numbers game with seven-digit voltmeter readouts, even though the last four digits were essentially just random numbers.

We even had a ludicrous situation where a firm called Tinsley, who used to manufacture the ultimate standards for the National Physical Laboratory (NPL), had to submit their equipment to the NPL to be given a certificate of calibration.

If we had rigidly followed the BSI requirements for calibrating an AVO meter by letting each reading settle for about an hour before accepting it, then it would have been far cheaper to purchase annually a new instrument with its maker's calibration certificate and simply throw away the old ones – as several firms in the UK aircraft industry actually did.

I still use my AVO 7 on the turnout range to measure the short-circuit current available from a rechargeable cell, which seems to be the only reliable way of doing this.

GS Chatley, by email

Matthew Pulzer replies:

I do agree about trusting excessive significant figures of accuracy from cheap equipment – something all of us should be careful to avoid.

Hunting for music

Dear editor
Do you know of any websites that sell/offer downloadable songs by Max Bygraves. I am looking for *100 minutes of Max Bygraves*, which was originally on tape (long play). Maybe by now it's on CD. It was issued in 1982 by PRT Records (ZCTON 104) and had a medley of old songs like *Me and My Shadow*, *Moonlight and Roses*, *You Are My Sunshine* and *Let Me Call You Sweetheart*.

I did ask a friend in the UK to source it for me, but he could not find it.

On a different matter, will Alan Winstanley be writing in *Circuit Surgery*?

Kenneth Bruyns, Penang, Malaysia

Alan Winstanley replies:

*I checked on Amazon (***amazon.co.uk***) for MP3 downloads and found a long list of Max Bygraves tracks (don't tell anyone, but I'm humming to* The Toothbrush Song *as I type...)*

I'm not sure if they are accessible to you from overseas, but try the following direct link and see what happens: **http://tinyurl.com/5r2g4m3**

Excerpts can be heard by clicking the small black button icon against each title. All his tracks are there, along with a number of albums, so you can mix your own selection.

Plan B would be to ask someone in the UK to put them on to an audio CD for you, copyright permitting. *They will be downloaded as MP3 files, and then a CD burning program would be needed to create an audio CD.*

Thank you for asking after Circuit Surgery*, which I inherited, from its creator Mike Tooley in the 1990s. The hobby has changed considerably over the years, and although* Circuit Surgery *was a blast at the time, I guess we all have to move with the times.*

In the days before email, I took literally carrier-bags full of post to the letterbox every month. Apart from anything else, I ran out of energy sticking all those stamps on letters! Ian Bell's work is extremely highly regarded and he does a fantastic job of grappling with all sorts of esoteric aspects of our hobby, so the column's more than safe in his hands.

Thanks for your continued interest, and best wishes

Alan Winstanley
EPE online editor

Readers can contact Alan by email at:
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The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

Also included are 29 *PIC N' Mix* articles, also republished from *EPE*. These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers. An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

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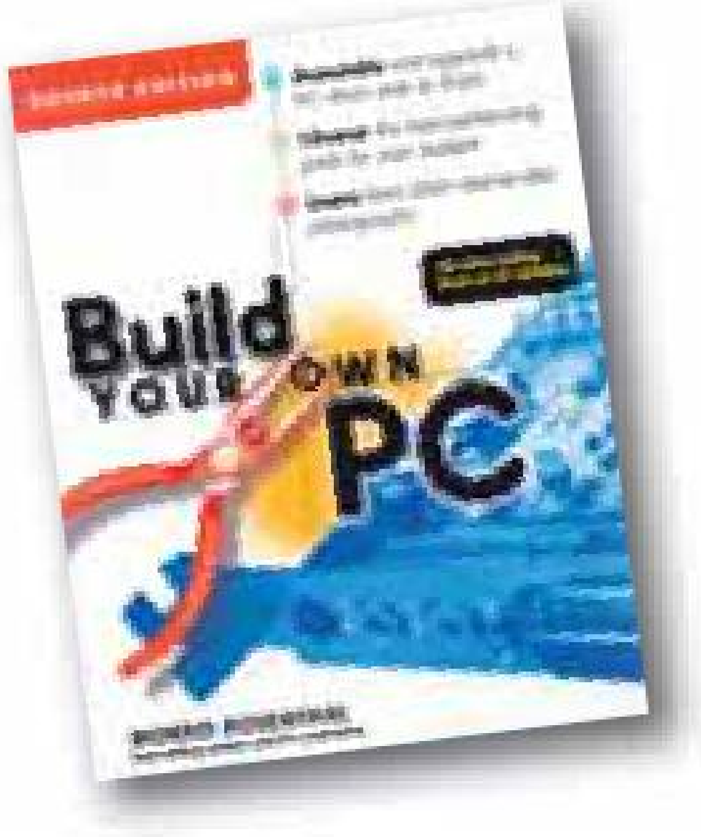

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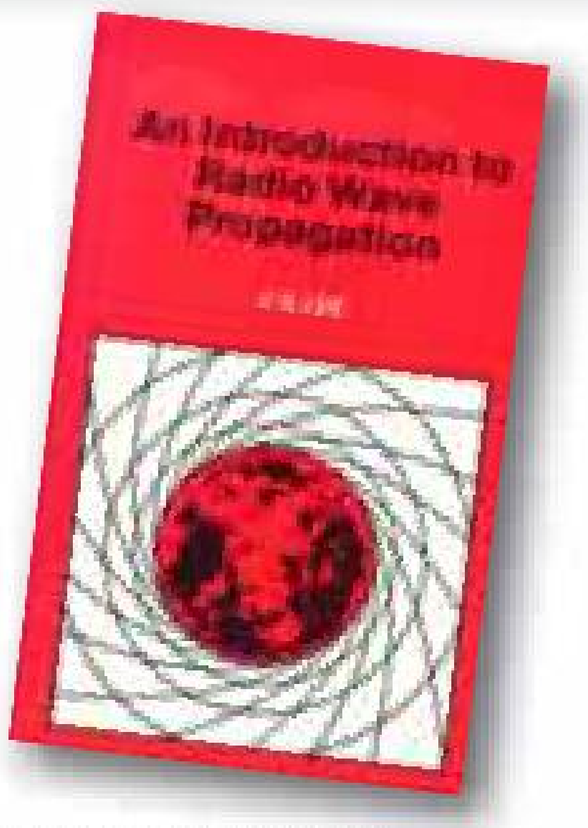

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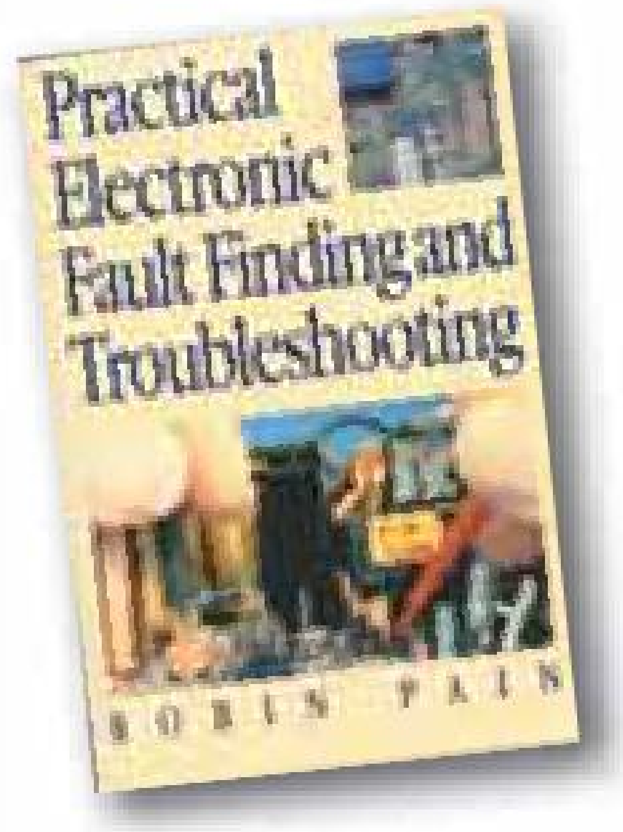

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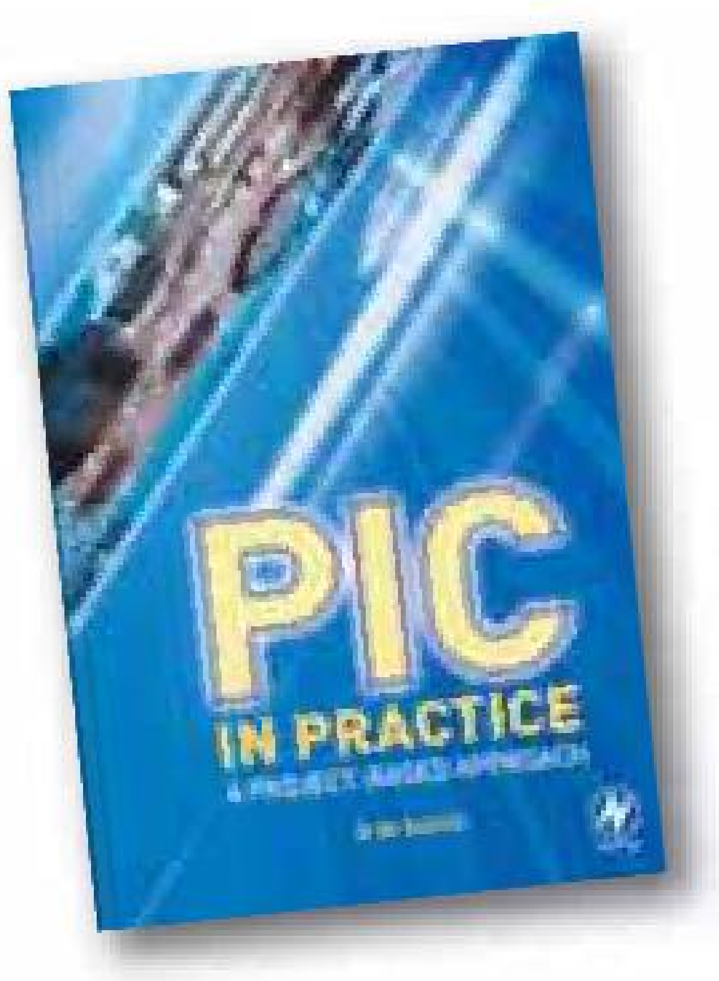

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Programming PICs: How It's Done

Many of our projects include a PIC microcontroller as the central component. But how do you program the PIC if you're not buying a kit or if you want to upgrade the firmware to a later version? Here's an easy-to-follow guide to doing it yourself.

GPS Car Computer – Part 2

In Part 1, we introduced our new GPS Car Computer and provided full constructional details. But there's a lot more that we haven't covered yet – make way for the software!

WIB: Web Server In a Box – Part 3

In Part 2, we showed you how to connect the WIB to a network and gave the step-by-step setting-up details. Most constructors will settle for the website provided, but for those with specialist needs, this third article will look at ways to customise the WIB for more advanced requirements.

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